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NORTHERN GREAT PLAINS RESOURCE PROGRAM, SURFACE RESOURCES WORK GROUP. IMPACT ANALYSIS

Northern Great Plains Resource Program

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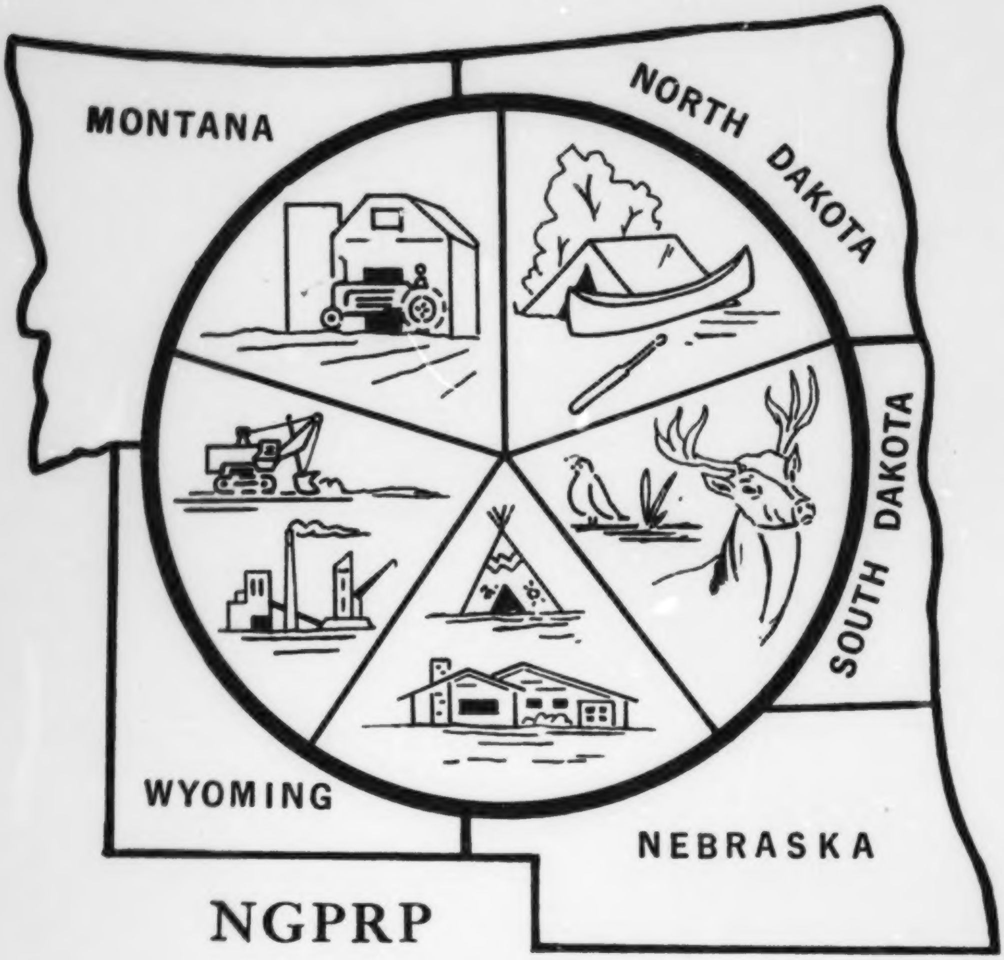
SURFACE RESOURCES WORK GROUP · IMPACT ANALYSIS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This report describes the impact on surface resources that could result from three alternative levels of potential coal development in the Northern Great Plains. A 63 county area of the states of North Dakota, Montana, Wyoming and South Dakota. It addresses 11 areas of potential impacts including: 1) Land resources; 2) Soils; 3) Vegetation; 4) Fish and wildlife resources; 5) Recreation resources; 6) Agricultural resources; 7) Wilderness-wild lands resources; 8) Scenery resources; 9) Forest-products; 10) Surface rehabilitation potentials and limitations; and 11) Eco-systems relationships. The purpose of this report is to present data on the significance of potential impacts that could result from different levels of coal mining and conversion. The present conditions are described in "Surface Resources Work Group-Regional Profile" report number NGPRP/CD-74/400.

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NORTHERN GREAT PLAINS RESOURCES PROGRAM

SURFACE RESOURCES WORK GROUP - IMPACT ANALYSES

DISCUSSION DRAFT

MARCH 1974

THIS REPORT WAS PREPARED PURSUANT TO A DIRECTIVE DATED OCTOBER 23, 1973, FROM THE PROGRAM MANAGER, NORTHERN GREAT PLAINS RESOURCES PROGRAM. PUBLICATION OF THE FINDINGS AND RECOMMENDATIONS HEREIN SHOULD NOT BE CONSTRUED AS REPRESENTING EITHER THE APPROVAL OR DISAPPROVAL OF THE SECRETARY OF THE INTERIOR, THE SECRETARY OF AGRICULTURE, THE ADMINISTRATOR OF THE ENVIRONMENTAL PROTECTION AGENCY, OR THE STATES OF MONTANA, NEBRASKA, NORTH DAKOTA, SOUTH DAKOTA, AND WYOMING. THE PURPOSE OF THIS REPORT IS TO PROVIDE INFORMATION AND ASSISTANCE TO THE PROGRAM MANAGEMENT TEAM IN THE PREPARATION OF THE DRAFT INTERIM REPORT ON THE NORTHERN GREAT PLAINS RESOURCES PROGRAM. THE PROGRAM MANAGEMENT TEAM IS RELEASING THIS DRAFT FOR PUBLIC USE WITHOUT CORRECTING INCONSISTENCIES OR REWRITING BECAUSE THE DELAY REQUIRED TO ACCOMPLISH THIS TASK WOULD DELAY THE TIMELY ISSUANCE OF THE REPORTS.

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Discussion Draft 1
March 1974

IMPACT ANALYSES ON SURFACE RESOURCES

SUMMARY

I. INTRODUCTION

The surface resources regional profile presented data depicting the abundance of resources in the Northern Great Plains Resources Program area. Factually, the approximately 143,000-square-mile area has a rich Western heritage of spacious lands and skies and a dominantly agrarian culture.

The advent of an accelerating fossil fuel industry warrants examination of the probable impact of alternative levels of coal development upon the area. This report addresses the impacts on surface resources and related topics by subjective analyses. These analytical procedures are outlined in the Appendix to this summary. A philosophical comment will appear later in this report.

II. RESULTS

Impacts discussed in this section relate to three levels of coal development termed: Base Forecast, Most Probable Forecast, and Extensive Forecast for the time frames of 1980, 1985, and 2000. Locations of projected mines and tonnages by time frames are indicated in the Appendix to this summary.

Impacts of mining developments on the various assigned resources and topics follow:

1. Land Resources. No attempt was made to analyze probable impacts on land resources, per se, as presented in the regional profile because essentially they will be covered as constituents of other analyses.

2. Soils. The unique set of biotic, chemical, and physical properties constituting a given soil-plant system will be destroyed by surface mining. It cannot be preserved intact. Soil structure will be altered; some soil micro-organisms will be lost; chemical properties will be changed; and water relations will be affected.

Before mining commences, it is essential that detailed studies of the sites be conducted to identify sensitive ecosystems, soil hazards, and rehabilitation potentials. Surface mining will increase the sediment-producing potential, but erosion will likely be less than in the East because rainfall and runoff are less and the topographic configuration differs.

The total impact of mining on agricultural production is likely to be low because the projected surface minable acreage is small, compared to the total acreage of land suitable for irrigated and dryland crops and rangeland.

For the Base Forecast, the net loss in capacity for farm and ranch production will be minor. For the Extensive Development Forecast, for the region, the loss in productive capacity of farms and ranches as a result of mining is expected to be less than 0.5 percent by 2000 with effective reclamation. Impacts of increased urban development on agricultural lands can be held to a minimum by proper zoning.

3. Vegetation. Surface mining and associated plants and facilitating structures will destroy the present vegetation. Restoration of

a vegetal cover comparable to the pre-mining cover will require extensive rehabilitation measures.

The impact of projected surface mining on domestic livestock production, the principal consumer of vegetation within the Northern Great Plains Resources Program area, is insignificant when viewed on a regional, state, or county basis. Projections for the Extensive Development Forecast for year 2000 indicate a total of 223,852 acres of rangeland rendered unavailable for grazing. This is the equivalent of grazing needs of 6,218 animal units on a yearlong basis, or only 0.0019 percent (less than 0.2 percent) of present livestock numbers in the region. The average displacement for the counties representing the four sample areas is only 0.92 percent.

Most of the natural plant communities in the Northern Great Plains developed under conditions of grazing use. Where areas may be excluded from grazing or converted to other vegetal cover, they will likely develop plant composition characteristics unlike the natural plant community because of the elimination of grazing as an environmental factor.

4. Fish and Wildlife. Two general conclusions warrant consideration: (a) with the probable exception of the peregrine falcon, no species will be exterminated from the NGPRP study area under any forecast; and (b) all game species which are currently hunted will be maintained on a regional basis as huntable

populations. These conclusions are tentative, having been based only on two changing conditions--land and people.

In the Base Forecast, habitat of Merriam's wild turkey may deteriorate to a level of serious concern throughout the region by the year 2000. Hunting for elk in central and western Montana and Wyoming and for sage grouse throughout the region may substantially change in character. In the four sample areas, several species of endangered birds and mammals may be adversely affected. The population of Campbell County, Wyoming may increase to levels disastrous to the American peregrine falcon and the black-footed ferret--each an endangered species. Also in Campbell County and Oliver and Mercer Counties, North Dakota, deer hunting may be seriously affected. Significant sage grouse habitat in Big Horn County, Montana will have been destroyed. Deer habitat in Rosebud County and Oliver and Mercer Counties will have been lost in serious amounts. Regional and local populations of most other species will be little affected.

In the Most Probable Forecast, by year 2000, loss of habitat--accompanied by an influx of people--will have substantial effects on some threatened species in the region.

Throughout the region, loss of good habitat for deer, antelope, sage grouse, and wild turkey will be of concern to game managers and the public. Hunting for all big-game species and for sage grouse and ring-necked pheasant will have substantially changed from present conditions. Resident and nonresident big-game hunters will likely be subjected to more rigidly controlled hunts and moderately reduced bag limits. Nonresident hunting may be moderately reduced, and residents will pay proportionately more for individual hunting privileges.

Concentration of development and people will be particularly adverse to wildlife resources in Oliver and Mercer Counties, North Dakota, and Campbell County, Wyoming. Effects on endangered species may be disastrous. Hunting for big game in these areas will likely be quite changed from present conditions. Hunting for upland game and waterfowl and fishing in Oliver and Mercer Counties may be so changed from what sportsmen now enjoy that long-term residents will consider nearby outdoor opportunities ruined. In Big Horn County, Montana, small trout streams of the Big Horn Mountains and the renowned fishery of the Big Horn River below Yellowtail Dam will be subjected to excessive fishing pressure.

By 1985, in the Extensive Development Forecast, effects on fish and wildlife resources will be as adverse as by the year 2000 in the Most Probable Forecast summarized above.

By the year 2000, deer, turkey, raptor, and endangered species habitat in the region will be noticeably affected Hunting conditions for deer and sage grouse will have definitely worsened. Elk and other big-game hunting in all of Montana and

Wyoming, and the important related nonresident guiding and outfitting industry will be materially changed.

Serious antelope, ring-necked pheasant, and waterfowl habitat losses will likely occur. Hunting for these species and for sharp-tailed grouse and forest grouse will be little affected by the projected development. Such non-game wildlife as passerine birds, small mammals, reptiles, and amphibians will be affected. Their losses will be subtle--difficult to document or even understand--, and the effects on them will probably last longer. Fishing pressures will rise, but shifting emphasis to less utilized species will mollify excessive local pressures.

In each of the four sample areas, adverse effects on wildlife will be greatly magnified. Raptors will be grossly affected by the mere presence of more people. Consumptive use of all big game in the four sample areas will be markedly changed. Hunters for all species in these areas may find restricted permits, shorter seasons, lower bag limits and success ratios, and greatly increased access problems. Existing fishing conditions in Big Horn County, Montana and Oliver and Mercer Counties, North Dakota will be changed.

5. Recreation. In the broadest sense, nearly all of the NGPRP area can be considered a recreation resource. From a narrower view, designated and potential recreation resources are

scattered within and adjacent to the more outstanding natural areas, the historic, archaeologic, and cultural areas. The impact analysis recognized impacts from associated developments, increased populations, physical disturbance of land, recreation use pressures, economic values, and danger to historical and scientific areas.

The most severe and direct impacts will occur in the near vicinity of those areas projected for major surface mining and development of power and gasification plants. Other areas that will be indirectly impacted are the several high quality recreation areas adjacent to the NGPRP area. The most important and long-lasting impact will be the change occurring to the entire region. Several adverse impacts on recreation resources recur throughout the impact analysis. The most direct impact is the acreage of the various types of recreation areas that will be altered by the disturbance of land during mining and related service facility construction.

Other adverse impacts, more indirect but just as significant, will occur over a much larger area. These include recreation use pressures and conflicts of interest created by a population influx, changes to the region's economy, and, more directly, increased costs for acquisition, development, operation, and maintenance of recreation facilities. Legal impacts will result, ranging from local law enforcement to interpretation and application of federal legislation. Historic and scientific features may be lost or suffer deterioration of specific sites.

A presently unknown impact that may be more pervading, yet not recognized for years, is the effect of stack emissions on both flora and fauna, ingredients of the recreation resources base.

6. Agriculture. Total acres disturbed in year 2000 in the Base Forecast are 37,570; Most Probable--129,640; and Extensive--308,544. Starting in 1980, the loss in wheat production under the Most Probable Forecast is about 2 percent of total wheat production in the area. Under the Extensive Development Forecast, the loss in wheat production is expected to be about 4.5 percent.

The loss, in numbers, of livestock occasioned by rangeland being taken out of production is less than one-half of 1 percent for the entire area (Extensive--year 2000). These estimates of impacts consider only actual areas for development; they do not include any impingement to acres surrounding the actual disturbance. Further, they do not consider the problems of dislocation of the rancher or farmer who may have only a part of his land involved in mining activities but of sufficient magnitude to render the remainder an uneconomic unit.

7. Wilderness-wild lands. Actual mining operations will have little effect on the inventoried wilderness-wild land resource. All impacts on existing areas of the Wilderness System will be caused indirectly by increased use or possible water modifications or developments. Increased use will result in some loss of opportunities for solitude within the Wildernesses. Visitors seeking solitude may have to penetrate further or pick seasons when use is light.

No proposed units to the National Wilderness Preservation System are directly affected by the projected mining operations. Any impacts will likely result from increased use or projects affecting waterflows from these areas.

There will likely be no direct impact on the inventoried wild lands (regional profile) in Mercer, Oliver, or Campbell Counties. Wild-land area No. 47 in Rosebud County will be affected by development under the Base Forecast, year 2000; and area No. 6 will be partially affected under the Extensive Forecast in year 2000.

In Big Horn County, area No. 15 and area No. 2 will be affected in year 2000.

8. Scenery. Analysis of impacts on scenery is limited to the four sample areas. It was determined that an impact analysis on a regional basis was impracticable. There is also a major problem of attempting to compare qualities among entirely different types of scenery, e.g., the scattered pines on hills

near Colstrip, Montana, versus the Knife River Valley in North Dakota.

Development of power and gasification plants and anticipated smoke plumes would have the greatest impact on scenic views. In Big Horn County, Montana, except for possible plume impact, the degree of impact is considered low.

In Rosebud County, the Yellowstone River Breaks will be impacted by gasification and power generation operations. The Open Country north of the Yellowstone will sustain very little scenic impact. The Scattered Ponderosa Pine and Open Parks south of the Yellowstone will likely be impacted as severely as any area in the Northern Great Plains, both by mining and atmospheric discharges.

In Mercer and Oliver Counties, North Dakota, the projected facilities development will likely add to the visual problem resulting from emissions. It is expected that this area will experience a severe impact because it will experience the brunt of a full-range coal development.

Mining operations, alone, are not expected to create a major scenic impact in Campbell County, Wyoming. However, because of the prairie setting, any substance ejected into the air may be visible over wide areas.

9. Forest Products. The impacts of all projected mining activities in the study area on both commercial forest land and sustained

timber products output are considered relatively insignificant. This conclusion is attributed, first, to the small proportion of the area involved, and, secondly, because of the very low current level of use of the existing wood resource compared with the potential use. Only Big Horn and Rosebud Counties, Montana are expected to lose commercial forest acreage, and that is only about 1 percent--even under the Extensive Forecast.

10. Surface Rehabilitation Potentials and Limitations. We believe that virtually all surface mined sites in the Northern Great Plains can be successfully rehabilitated. Sites having the highest rehabilitation potentials occur in rehabilitation response units characterized by productive and stable soils, suitable and available plant species, and adequate amounts of precipitation. In general, these high potential sites occur in west-central North Dakota. Surface minable sites having intermediate rehabilitation potentials occur predominantly in southeastern Montana and extreme western North Dakota. Sites having the poorest potentials for rehabilitation occur in northeastern Wyoming and northeastern Montana, where rehabilitation response units are characterized by poorly productive soils, native species which grow slowly and are difficult to obtain for rehabilitation purposes, and low amounts of precipitation.

Fortunately, those portions of the Northern Great Plains that present the most difficult rehabilitation problems are also the portions where the smallest areas will be disturbed for a given amount of extracted coal. Conversely, the easiest rehabilitation problems exist in those portions of the Northern Great Plains where the greatest areas of disturbance take place per unit of extracted coal.

Comparisons of the rehabilitation potential ratings indicate lack of uniformity in the relative ease or difficulty of the rehabilitation job with a shift from one development forecast to another and from one time frame to another. We conclude that, based on the information contained in this report, restructuring of mining developments between time frames within each development forecast could be accomplished by reselecting for mining during each time frame the combination of rehabilitation response units that are collectively of the same--or nearly the same--rehabilitation potential ratings from time frame to time frame. This would greatly enhance the uniformity of and, hence, the standardization of, rehabilitation activities and programs in the Northern Great Plains coalfields.

Neither the federal Government nor the states have adequate laws governing surface mine rehabilitation in the Northern Great Plains. There is no federal law, and the state laws do not have uniformly adequate provisions to assure the application of known technology for rehabilitation of surface mined lands. Better laws and effective enforcement will be required before the best rehabilitation technology will be applied effectively to the land.

11. Ecosystem Relationships. A general assessment of the potential impacts of coal development on the ecosystems of the Northern Great Plains can be made; however, there is no equation between the percentage of an ecosystem, county, or the entire region to be disturbed and the degree of impact that may result.

At first glance, analyses data reveal that relatively small proportions of each ecosystem will be directly affected by coal development. The same is true of the four counties and the entire region. In some respects, these data are a trap that can lead to more optimistic conclusions than are really warranted. When one realizes that only 0.05 percent of an ecosystem will be disturbed, the first reaction may be that there is really no major cause for alarm. However, these data only reveal the direct impacts of disturbance, and do not indicate the more indirect effects. The almost insidious effects of mineral development are, at first glance, subtle and somewhat below the surface. Such almost subtle relations as the nesting areas for key symbiotic insects and annual plants, or the niches for certain soil micro-organisms or endangered vascular plant species must be considered.

The impact analyses data indicate that the most severe impacts will result on the moderately arid ecosystems, and that the counties supporting them will be affected most detrimentally. As expected, the Base Forecast will lead to the least disturbance, and the Extensive Forecast will result in the most. A similar conclusion can be drawn about the entire region. Generally, however, it can be concluded that some ecosystem relationships will be disrupted for many generations to come under all three forecasts; and, indeed, some may be lost forever. It would seem to be highly presumptuous at this point to decide what relationships we can forego, when we scarcely know the kinds of complex ecological interactions that exist in the first place.

Having presented as complete a regional profile as time and existing data permitted; having considered legal, cultural, ecological, and informational constraints that influence coal development; and having conducted subjective analyses of the impacts of projected coal developments on surface resources--what does it all mean?

The Work Group Leader addresses certain key issues in summary.

The Mineral Resources Work Group reports total surface minable coal reserves of 68,138,000,000 tons. (Another report estimates perhaps an additional 10 billion tons in eastern Montana.) These coal reserves underlie only 2.84 percent (2,599,913 acres) of the NGPRP area delineated by this Work Group.

Assuming the Base Forecast to hold, the surface minable coal reserves are adequate for 595 years. Under provisions of the Most Probable Forecast, these reserves are adequate for 195 years. Should the Extensive Forecast that provides for mining about 983 million tons of coal each year by 2000 materialize, the reserves will suffice for 69 years. Obviously, the country is not going to be torn asunder by coal mining overnight. This should assuage considerable emotional concern. However, it is insufficient cause to dismiss the impacts as inconsequential. Numerous other values and impacts must be considered.

The regional profile established the abundant economic, esthetic, and ecological values of the NGPRP area. Some values are tangible; others intangible. Some, if damaged, can be reclaimed; others could be lost. The Northern Great Plains is a spacious area, noted for distance and uncrowded conditions. Recreational opportunities abound; historical sites are numerous; wildlife and fish are abundant; grain and livestock production contribute significantly to the nation's market basket; forest products are important locally but are probably underutilized; outstanding wilderness experiences are nearby; a wide array of soils occur that differ in productivity and stability; and natural vegetation is highly diverse.

This area provides outstanding big-game hunting, particularly for deer and antelope. An estimated 75 percent of the world population of antelope inhabit this area. It is likewise an important sage grouse habitat, and also supports a large population of golden eagles.

Probably the issue of most concern relates to rehabilitation of surface disturbance. Without successful rehabilitation, mined lands are unsightly, unproductive, and constitute a sediment source. Problems encountered in rehabilitating spoils often relate to erosion where spoil slopes are too steep, where erosion is intensified, where seed are washed away, and where vital moisture is lost as runoff. Chemical and physical properties of soils are often ignored.

We believe that practically all areas projected for surface mining can be rehabilitated--or revegetated. But thorough rehabilitation planning is essential. Efforts at rehabilitation must be determined, dedicated, and continuing. A one-shot treatment cannot be relied upon because of the inherent variations in soil characteristics and the vagaries of the weather. Exotic or introduced species may provide quicker and denser cover than native plants, but we have insufficient knowledge to predict their durability over time and under use. We know that native plants usually require a longer period for establishment, but, again, we lack knowledge of the time frame or their adaptability to a totally disrupted growth medium.

The important question is: "Can surface mining be conducted in harmony with associated resources?" The need for mineral resources to undergird the nation's economy and our energy-dependent way of life must be weighed against the values of the other resources. The decision will rest upon what is best for the greatest number of people over time. With a constantly broadening knowledge base and technological advances, the extraction of needed minerals should, in time, become more compatible with other resources.

Discussion Draft
March 1974

KNOWLEDGE GAPS

Wilderness

1. Inventory, identify, and study wild lands within the Northern Great Plains having potential as wilderness areas, so that administrative action may be taken to insure the preservation of a substantial representation of this unique natural environment.

2. Develop a system that will allow the decisionmaker to adequately and visibly evaluate the effects of mineral development on these lands.

Scenery (combined with Recreation and Wilderness)

A method by which scenic values may be quantified rather than adjectively described.

Recreation

1. Land use planning programs are needed on a local, state, and regional basis to provide a means of controlling development and its implication.

2. Recreation data are needed on the role that the private sector can be expected to play in providing outdoor recreation opportunities.

3. Locations and boundaries of existing and potential recreation resources in the study area are needed so that plans for their protection or development can be encouraged commensurate with coal development.

4. Specific identification and location of historic, unique, scientific, and archaeological areas and their values.

5. Effects of changes in streamflow and reservoir regulation on recreation resources and uses need more in-depth analysis.

6. Effects of changed economic and social patterns on recreation uses and the recreation industry needs a more thorough analysis.

7. Recreation carrying capacity of resources that will be impacted by coal-related development needs detailed analysis.

8. Implications and effects (constraints) that the numerous recreation and conservation-related laws and regulations will have on coal development and on recreation needs to be analyzed.

Forest Products

1. More detailed data on commercial forest land are needed to more accurately estimate the potential production of sawlogs, pulpwood, mine timbers, posts, fuelwood, and other timbers.

Soils

1. Detailed soil surveys are needed in advance of all proposed mining to provide basic information concerning the limitations of soils to agricultural potential, rehabilitation potential, degrees of grading and soil placement that can be tolerated, and desirable location of urban facilities.

Rehabilitation

1. Research is needed to determine the optimum methods and techniques for rehabilitating disturbed sites in an acceptable manner so that the land can be returned to its former condition, or to a use supporting higher productivity. Detailed needs include:

   (a) Analysis and evaluation of chemical and physical characteristics of surface mine overburden materials in relation to their suitability for revegetation purposes.

   (b) Methods and techniques for creating favorable microbiological activity in previously sterile surface mine spoils.

   (c) Testing and evaluating the comparative effects of different organic soil amendments in revegetating surface mine spoils.

   (d) Testing and evaluating the comparative effects of selected inorganic fertilizers in revegetating surface mine spoils.

   (e) Evaluation of the physical and chemical quality of surface and subsurface runoff water from mine spoils under different rehabilitation treatments.

   (f) Mechanical-chemical, vegetative techniques for rehabilitating steep, abandoned surface mine spoils.

   (g) Evaluation of the effectiveness of successful semiarid farming techniques on various kinds of mine spoils.

   (h) Testing and evaluating various spoil segregations and configurations to enhance rehabilitation success.

(i) Mechanical criteria for constructing mine dumps to prevent mass slumping and reduce surface erosion.

(j) Determining the physiological tolerances of selected plant ecotypes to various soil-water potential and atmospheric evaporative demand stresses on surface mine spoils.

(k) Determining physiological tolerances of selected plant ecotypes to saline-alkaline stresses on various kinds of surface mine spoils.

(l) Testing and evaluating hormone-stimulated rooting success of native shrubs on abandoned, oversteep mine spoils.

(m) Tissue culturing techniques to develop increased tolerances of selected plant ecotypes to saline-alkaline stresses on surface mine spoils.

(n) Determining permanency and stability of exotic species as suitable vegetal cover on mined areas.

Vegetation

1. Inventory, identify, and study the rare and endangered plant species by sites to be mined. This should be completed in the areas that will be mined well in advance of development to insure that protective measures can be taken.

2. Inventory, identify, protect, and study natural areas which still support plant communities substantially representing the potential productivity of specific soil and climatic units.

3. Production data for major range sites (especially yield information extending over a period of years) to characterize variations in yield during favorable and less favorable years.

4. The nature and extent of normal fluctuations in species composition within relatively stable plant communities.

5. Identify "key" range sites (such as meadows, bottom lands, etc.) which are of unusual significance in livestock production.

Fish and Wildlife

1. Inventory, identify, and study the rare and endangered animal species in the areas that are scheduled for coal development. Undertake well in advance of any mining operations so that administrative action can be taken to protect them.

2. Determine the future of the population of pronghorn antelope in relation to projected mining.

3. Determine the future of hunting the population of sage grouse as it may be affected by mining.

4. What is the future of the nesting population of golden eagles and the wintering populations of golden and bald eagles in the Western United States in respect to accelerated mineral development?

5. Sufficient water resource use data to permit meaningful analysis of impacts on such aquatic resources as fish, aquatic invertebrates, aquatic vertebrates (amphibians and reptiles), water birds, waterfowl, furbearing mammals.

6. What effects will stack emissions of power generation and coal gasification plants have on fish and wildlife and their habitat?

Ecosystems

1. Detailed onsite characterizations of the ecosystems are needed in the areas to be mined or otherwise developed. These studies should identify the fundamental interactions among the various biological and physical components of each ecosystem.

Draft
March 1974

APPENDIX I

ANALYTICAL METHODOLOGY

The Surface Resources Work Group developed "analytical methodology" to guide each subgroup in analyzing the impacts of projected forecasts of coal development on surface resources. Components consisted of: (a) basic assumptions, (b) steps in analysis, (c) rules for analysis, (d) quantified definition of development levels (Tables 1 and 2), and (e) matrix forms.

The Work Group recognized at the outset that only subjective analyses were possible. Nevertheless, by employing a uniform and systematic approach, using matrix forms on which "affected factors," and degree and magnitude of disturbance were recorded, reasonably accurate approximations of impacts could be determined. These formed the basis of the impacts reported in the following sections.

Local sample areas selected for intensive analyses were:

Campbell County, Wyoming
Big Horn County, Montana
Rosebud County, Montana
Mercer County)
) North Dakota
Oliver County)

Considering Mercer and Oliver Counties as a single area, the local areas represent four sample areas where intensive mining developments are projected. Collectively, these four sample areas represent 89 percent of coal production in the Base Forecast for year 2000; 61 percent of the Most Probable Forecast; and 61 percent of the Extensive

Development Forecast. Thus, by far a majority of regional coal development is represented in the four sample areas.

Certain basic assumptions were prerequisite to the analyses. Thirteen were developed for the Work Group, with the provision that each subgroup develop additional ones as needed for its particular resource or consideration.

BASIC ASSUMPTIONS

1. All mined lands will, as a minimum, be returned to current vegetal cover and use as nearly as possible.
2. Mined areas will have soil (overburden) replaced in same sequence as present within 1 year following mining.
3. Existing laws, regulations, and requirements will remain constant and in effect during the projection period (year 2000).
4. Enhancement of some reclaimed mined lands will occur.
5. Plant sites, reservoirs, transmission corridors, roads, towns, etc. will remain in place during all time frames through the projection period.
6. Level of mining technology will not change significantly through 1985.
7. Coal seam depths vary according to the particular formations. Assume depths indicated in Tables 1 and 2.
8. Assume the following acreages to be relegated to uses indicated for the duration of the projection period, dating from the time frame of establishment or operation:

Gasification plant site..................	1,000 acres
Gasification plant reservoir.............	30 "
Power generation plant...................	100 "
Power generation reservoir...............	50 "
Mine facility acreages	
Capacity less than 5 MMtpy.............	149 "
Capacity, 5 to 10 MMtpy................	150 "
Capacity more than 10 MMtpy............	153 "

9. No additional acreage allowed for either cleaning plant or tailings pond, if required.

10. An acre foot of coal (80% efficiency in recovery) yields 1,416 tons.

11. Assume the following conditions for mined lands:

Campbell County, Wyo. Mining disturbance will affect only productive rangeland. Assume 4 acres per Animal Unit Month grazing. No cropland, no forest will be affected.

Big Horn County, Mont. Mining disturbance will affect land resources thusly:

> Rangeland 80%; forest land 10%; cropland 10%, divided equally between wheat and alfalfa. Use production data enclosed.

Rosebud County, Mont. Mining disturbance will affect land resources thusly:

> Rangeland 80%; forest land 15%; and cropland 5%--wheat. Use production data enclosed.

Mercer and Oliver Counties, N.D. Best estimate available for probable land resource disturbance is:

Mercer County: 55% rangeland; 45% cropland.

Oliver County: 70% rangeland; 30% cropland.

Assume for purpose of analysis, combining both counties: 60% rangeland; 40% cropland. Assume cropland affected thusly: one-half wheat, one-fourth oats, one-fourth alfalfa hay.

12. Assume 5 years as time requirement to return mined acreage to stable productive cropland. Assume 5 years to regenerate, by planting, forest land. Assume 10 years to return rangeland to stable and productive grazing condition. For such uses as wildlife habitat, scenery, etc., assume a minimum of 25 years.
13. Assume 17,000 acre feet of water requirement for a gasification plant and 15,000 acre feet for a wet-tower cooling electric power generator.

Table 1. Quantified mining activities for the base, most probable, and extensive development forecasts for the four selected sample areas.

BASE FORECAST (Ref. Maps 1 & 2)

Map no.	Map ref. no.	Mine identification	Use	Production Millions tons per year 1972	1980	1985	2000	Aver. BTU lb.	Seam thick-ness (feet)	Acres disturbed by mining (yearly) 2000[1/]	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
		WYOMING - CAMPBELL COUNTY											
1	1	Wyodak		0.62	1.5	1.5	1.5		70	16.0		149	
1	2	Amax-Belle Ayr		.03	9.5	9.5	9.5		70	96.0		150	
1	7	Carter				?							
1	8	ARCO		0	7.0	7.0	7.0		35	142.0		150	
1	10	Ker-McGee		0	7.0	7.0	7.0		35	142.0		150	
2	1		Power gener.				4.7	8300	25	133	100	149	50
2	1		Export				2.0	8320	70	21		149	
		MONTANA - BIG HORN COUNTY											
1	11	Decker		0.8	13.0	13.0	13.0		50	184		153	
1	12	Sarpy Creek		0	4.0	4.0	4.0		55	52		149	
2	2		Power gener.				3.5	9650	55	45	100	149	50
2	3		" "				3.9	8450	55	51	100	149	50
2	2		Export				2.0	9600	55	26		149	
		ROSEBUD COUNTY											
1	13	Peabody-Big Sky		1.6	4.0	4.0	4.0		25	113		149	
1	14	West.Energy-Colstrip		5.5	19.32	19.32	19.32		25	546		153	
2	4		Power gener.				3.8	8850	20	135	100	149	50
		NORTH DAKOTA - MERCER COUNTY											
1	21	No.Amer. Indianhead		1.04	1.2	1.2	1.2		12	71		149	
1	22	Knife River-Beulah		1.53	1.5	1.5	1.5		12	89		149	
2	6		Power gener.				5.7	6870	10	403	100	149	50
		OLIVER COUNTY											
1	20	Baukol Noonan		1.44	4.5	4.5	4.5		10	318		149	
1	23	Consolid.-Glenharold		1.42	4.0	4.0	4.0		14	202		149	

1/ Where 1980 figures differ from year 2000, acres disturbed for 1980 are also shown.

Table 1 (Cont'd)

MOST PROBABLE FORECAST (Ref. Maps 1 & 3)

Map no.	Map ref. no.	Mine identification	Use	Production Millions tons per year 1972	1980	1985	2000	Aver. BTU lb.	Seam thick-ness (feet)	Acres disturbed by mining (yearly) 2000 1/	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
		WYOMING - CAMPBELL COUNTY											
1	1	Wyodak		0.62	1.5	1.5	1.5		70	16.0		149	
1	2	Amax-Bell Ayr		.03	9.5	9.5	9.5		70	96.0		150	
1	7	Carter				?							
1	8	ARCO		0	7.0	7.0	7.0		35	142.0		150	
1	10	Kerr-McGee		0	7.0	7.0	7.0		35	142.0		150	
3	2		Gasification			8.3	8.3	8320	70	84.0	1,000	150	30
3	1		Power gener.				4.7	8300	25	133.0	100	149	50
3	2		Export		6.0	6.0	6.0	8320	70	61.0		150	
3	1		"			6.0	6.0	8100	35	122.0		150	
3	3		"				9.0	8300	25	255.0		150	
		MONTANA - BIGHORN COUNTY											
1	11	Decker		0.8	13.0	13.0	13.0		50	184		153	
1	12	Sarpy Creek		0	4.0	4.0	4.0		55	52		149	
3	4		Gasification			7.1	7.1	9650	55	92	1,000	150	30
3	5		"			7.2	7.2	8000	55	93	1,000	150	30
3	6		"				8.0	8600	55	103	1,000	150	30
3	2		Power gener.				3.5	9650	55	45	100	149	50
3	3		" "				3.9	8450	55	51	100	149	50
3	5		Export		4.0	6.0	6.0	9600	55	78 (yr. 1980 52)		(yr.1980-149 150	
		ROSEBUD COUNTY											
1	13	Peabody-Big Sky		1.6	4.0	4.0	4.0		25	113		149	
1	14	West.Energy-Colstrip		5.5	19.32	19.32	19.32		25	546		153	
3	7		Gasification			7.9	7.9	8700	20	279	1,000	150	30
3	8		"				7.9	8700	20	279	1,000	150	30
3	4		Power gener.				3.8	8850	20	135	100	149	50
3	7		Export			7.0	7.0	8800	20	248		150	
3	8		"				9.5	8500	20	336		150	

1/ Where 1980 figures differ from year 2000, acres disturbed for 1980 are also shown.

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Table 1 (Cont'd)

MOST PROBABLE FORECAST (Ref. Maps 1 & 3)

Map no.	Map ref. no.	Mine identification	Use	Production Millions tons per year 1972	1980	1985	2000	Aver. BTU lb.	Seam thick-ness (feet)	Acres disturbed by mining (yearly) 2000 1/	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
						NORTH DAKOTA - MERCER COUNTY							
1	21	No.Amer. Indianhead		1.04	1.2	1.2	1.2		12	71		149	
1	22	Knife River-Beulah		1.53	1.5	1.5	1.5		12	89		149	
3	13		Gasification			10.0	10.0	6900	10	707	1,000	150	30
3	14		"				10.0	6900	10	707	1,000	150	30
3	11		Power gener.				5.9	6870	10	417	100	150	50
								OLIVER COUNTY					
1	20	Baukol Noonan		1.44	4.5	4.5	4.5		10	318		149	
1	23	Consolid.-Glenharold		1.42	4.0	4.0	4.0		14	202		149	
3	10		Power gener.				5.7	7070	10	403	100	150	50

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Table 1 (Cont'd)

EXTENSIVE DEVELOPMENT FORECAST (Ref. Maps 1 & 4)

Map no.	Map ref. no.	Mine identification	Use	Production Millions tons per year 1972	1980	1985	2000	Aver. BTU lb.	Seam thick- ness (feet)	Acres disturbed by mining (yearly) 2000 1/	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
						WYOMING - CAMPBELL COUNTY							
1	1	Wyodak		0.62	1.5	1.5	1.5		70	16.0		149	
1	2	Amax-Belle Ayr		.03	9.5	9.5	9.5		70	96.0		150	
1	7	Carter				?							
1	8	ARCO		0	7.0	7.0	7.0		35	142.0		150	
1	10	Kerr-McGee		0	7.0	7.0	7.0		35	142.0		150	
4	2		Gasification			8.3	8.3	8320	70	84.0	1,000	150	30
4	3		"			8.3	8.3	8320	70	84.0	1,000	150	30
4	4		"			8.3	3.3	8320	70	84.0	1,000	150	30
4	5		"			8.3	8.3	8320	25	235.0	1,000	150	30
4	6		"				8.3	8320	25	235.0	1,000	150	30
4	1		Power gener.				4.7	8300	25	133.0	100	149	50
										(yr.1980 61.0)		(Yr.1980-150)	
4	9		Export		6.0	10.0	10.0	8320	70	101.0		150	
4	2		"			10.0	10.0	9000	35	202.0		150	
4	5		"			10.0	10.0	8600	70	101.0		150	
4	18		"			10.0	10.0	8300	25	283.0		150	
4	3		"				10.0	8600	70	101.0		150	
4	4		"				10.0	8600	70	101.0		150	
4	6		"				10.0	8500	70	101.0		150	
4	7		"				10.0	8500	70	101.0		150	
4	8		"				10.0	8500	70	101.0		150	
4	10		"				10.0	8320	70	101.0		150	
4	11		"				10.0	8320	70	101.0		150	
4	12		"				10.0	8320	70	101.0		150	
4	13		"				10.0	8320	70	101.0		150	
4	14		"				10.0	8320	70	101.0		150	
4	15		"				10.0	8320	70	101.0		150	
4	16		"				10.0	8320	70	101.0		150	
4	17		"				10.0	8320	25	283.0		150	
4	19		"				10.0	8300	25	283.0		150	

1/ Where 1980 figures differ from year 2000, acres disturbed for 1980 are also shown.

Table 1 (Cont'd)

EXTENSIVE DEVELOPMENT FORECAST (Ref. Maps 1 & 4)

Map no.	Map ref. no.	Mine identification	Use	Production Millions tons per year 1972	1980	1985	2000	Aver. BTU lb.	Seam thickness (feet)	Acres disturbed by mining (yearly) 2000[1/]	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
							MONTANA - BIGHORN COUNTY						
1	11	Decker		0.8	13.0	13.0	13.0		50	184		153	
1	12	Sarpy Creek		0	4.0	4.0	4.0		55	52		149	
4	10		Gasification		7.1	7.1	7.1	9650	55	92	1,000	150	30
4	12		"			7.2	7.2	8000	55	93	1,000	150	30
4	13		"			8.0	8.0	8400	55	103	1,000	150	30
4	11		"				7.1	9650	55	92	1,000	150	30
4	14		"				8.0	8600	55	103	1,000	150	30
4	15		"				8.0	8600	55	103	1,000	150	30
4	16		"				8.0	8600	55	103	1,000	150	30
4	18		"				8.2	8400	55	106	1,000	150	30
4	21		"				7.9	8700	55	102	1,000	150	30
4	2		Power gener.				3.5	9650	55	45	100	149	50
4	3		" "				3.9	8450	55	51	100	149	50
4	25		Export		4.0	9.0	9.0	9600	55	(Yr.1980 52) 116		(Yr.1980-149) 150	
4	28		"			10.0	10.0	7640	55	129		150	
4	26		"				10.0	9600	55	129		150	
4	27		"				10.0	9600	55	129		150	
4	29		"				10.0	8450	55	129		150	
4	30		"				10.0	8390	55	129		150	
4	31		"				10.0	8470	55	129		150	

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1/ Where 1980 figures differ from year 2000, acres disturbed for 1980 are also shown.

Table 1 (Cont'd)

EXTENSIVE DEVELOPMENT FORECAST (Ref. Maps 1 & 4)

Map no.	Map ref. no.	Mine identification	Use	Production Millions tons per year 1972	1980	1985	2000	Aver. BTU lb.	Seam thickness (feet)	Acres disturbed by mining (yearly) 2000[1]	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
						MONTANA - ROSEBUD COUNTY							
1	13	Peabody-Big Sky		1.6	4.0	4.0	4.0		25	113		149	
1	14	West.Energy-Colstrip		5.5	19.32	19.32	19.32		25	546		153	
4	19		Gasification		7.9	7.9	7.9	8700	20	279	1,000	150	30
4	17		"			8.2	8.2	8400	20	290	1,000	150	30
4	20		"			7.9	7.9	8700	20	279	1,000	150	30
4	22		"			8.4	8.4	8170	20	297	1,000	150	30
4	4		Power gener.				3.8	8850	20	135	100	149	50
4	32		Export			10.0	10.0	8800	20	354		150	
4	34		"			10.0	10.0	8500	20	354		150	
4	33		"				10.0	8470	20	354		150	
4	35		"				10.0	8400	20	354		150	
4	36		"				10.0	8400	20	354		150	
						NORTH DAKOTA - MERCER COUNTY							
1	21	No.Amer. Indianhead		1.04	1.2	1.2	1.2		12	71		149	
1	22	Knife River-Beulah		1.53	1.5	1.5	1.5		12	89		149	
4	33		Gasification		10.0	10.0	10.0	6900	10	707	1,000	150	30
4	34		"		10.0	10.0	10.0	6900	10	707	1,000	150	30
4	35		"			10.0	10.0	6900	10	707	1,000	150	30
4	36		"				10.0	6900	10	707	1,000	150	30
4	37		"				10.0	6900	10	707	1,000	150	30
4	11		Power gener.				5.9	6870	10	417	100	150	
							OLIVER COUNTY						
1	20	Baukol Noonan		1.44	4.5	4.5	4.5		10	318		149	
1	23	Consolid.-Glenharold		1.42	4.0	4.0	4.0		14	202		149	
4	10		Power gener.				5.7	7070	10	403	100	150	50
4	48		Export				6.0	7000	10	424		150	

1/ Where 1980 figures differ from year 2000, acres disturbed for 1980 are also shown.

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Table 2a (Supplemental) Quantified mining activities for the base, most probable, and extensive development forecasts in counties other than the selected sample areas.

Map no.	Map ref. no.	County	State	Use	Production Millions tons per year 1980	1985	2000	Seam thickness (feet)	Acres disturbed by mining (yearly) 2000 1/	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
							BASE FORECAST (Map 2)		(Yr.1980-17)			
2	5	Sheridan	Wyo.	Export	1.0	2.0	2.0	43	33		149	
2	15	Richland	Mont.	Power gener.	0.3	0.3	0.3	17	13	100	149	50
2	16	Musselshell	Mont.	Export	0.2	0.2	0.2	8	18		149	
2	25	McHenry	N.D.	Export	0.5	0.5	0.5	14	26		149	
2	26	Adams	N.D.	Export	3.0	3.0	3.0	20	106		149	
							MOST PROBABLE FORECAST (Map 3)		(Yr.1980-17)			
3	5	Sheridan	Wyo.	Export	1.0	2.0	2.0	43	33		149	
3	15	Richland	Mont.	Power gener.	0.3	0.3	0.3	17	13	100	149	50
3	16	Musselshell	Mont.	Export	0.2	0.2	0.2	8	18		149	
3	25	McHenry	N.D.	Export	0.5	0.5	0.5	14	26		149	
3	26	Adams	N.D.	Export	3.0	3.0	3.0	20	106		149	
							EXTENSIVE DEVELOPMENT FORECAST (Map 4)		(Yr.1980-17)			
4	5	Sheridan	Wyo.	Export	1.0	2.0	2.0	43	33		149	
4	15	Richland	Mont.	Power gener.	0.3	0.3	0.3	17	13	100	149	50
4	16	Musselshell	Mont.	Export	0.2	0.2	0.2	8	18		149	
4	25	McHenry	N.D.	Export	0.5	0.5	0.5	14	26		149	
4	26	Adams	N.D.	Export	3.0	3.0	3.0	20	106		149	

1/ Where figures for 1980 differ from year 2000, acres disturbed for 1980 are also shown.

Table 2. Quantified mining activities for the base, most probable, and extensive development forecasts in counties other than the selected sample areas.

Map no.	Map ref. no.	County	State	Use	Production Millions tons per year 1980	1985	2000	Seam thick-ness-(feet)	Acres disturbed by mining (yearly) 2000[1/]	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
					BASE FORECAST (Map 2)							
2	5	McCone	Mont.	Power gener.			4.4	10	310	100	149	50
2	3	Slope	N.D.	Export			2.0	20	707	-	149	-
					MOST PROBABLE FORECAST (Map 3)							
3	1	Converse	Wyo.	Gasification		7.2	7.2	35	146	1,000	150	30
3	3	Johnson	Wyo.	"			8.7	130	48	1,000	150	30
3	9	Powder River	Mont.	"			8.2	35	166	1,000	150	30
3	10	Dunn	N.D.	"		10.1	10.1	10	714	1,000	153	30
3	11	Dunn	N.D.	"			10.1	10	714	1,000	153	30
3	12	Dunn	N.D.	"			10.1	10	714	1,000	153	30
3	15	McLean	N.D.	"			9.7	10	686	1,000	150	30
3	16	McLean	N.D.	"			9.7	10	686	1,000	150	30
3	5	McCone	Mont.	Power gener.			4.4	10	310	100	149	50
3	6	Slope	N.D.	" "			5.9	20	209	100	150	50
3	7	Hettinger	N.D.	" "			6.8	10	481	100	150	50
3	8	Hettinger	N.D.	" "			6.8	10	481	100	150	50
3	9	Billings	N.D.	" "			6.5	10	460	100	150	50
3	4	Sheridan	Wyo.	Export			9.0	40	159	-	150	-
3	6	Powder River	Mont.	"			9.5	35	192	-	150	-
3	9	Slope	N.D.	"		3.0	6.0	20	212	-	150	-
									(Yr.1980-106)		(Yr.1980-149)	

1/ Where figures for 1980 differ from year 2000, acres disturbed for 1980 are also shown.

Table 2 (Cont'd)

Map no.	Map ref. no.	County	State	Use	Production Millions tons per year 1980	1985	2000	Seam thick-ness (feet)	Acres disturbed by mining (yearly) 2000[1]	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
EXTENSIVE DEVELOPMENT FORECAST (Map 4)												
4	1	Converse	Wyo.	Gasification		8.5	8.5	35	172	1,000	150	30
4	9	Johnson	Wyo.	"		8.7	8.7	130	47	1,000	150	30
4	7	Johnson	Wyo.	"			8.7	130	47	1,000	150	30
4	8	Johnson	Wyo.	"			8.7	130	47	1,000	150	30
4	23	Powder River	Mont.	"	8.2	8.2	8.2	35	166	1,000	150	30
4	24	Powder River	Mont.	"			8.2	35	166	1,000	150	30
4	26	Dunn	N.D.	"	10.1	10.1	10.1	10	714	1,000	153	30
4	27	Dunn	N.D.	"	10.1	10.1	10.1	10	714	1,000	153	30
4	39	McLean	N.D.	"		9.7	9.7	10	686	1,000	150	30
4	25	Stark	N.D.	"			10.9	10	770	1,000	153	30
4	28	Dunn	N.D.	"			10.1	10	714	1,000	153	30
4	29	Dunn	N.D.	"			10.1	10	714	1,000	153	30
4	30	Dunn	N.D.	"			10.1	10	714	1,000	153	30
4	31	Dunn	N.D.	"			10.1	10	714	1,000	153	30
4	32	Dunn	N.D.	"			10.1	10	714	1,000	153	30
4	40	McLean	N.D.	"			9.7	10	686	1,000	150	30
4	41	McLean	N.D.	"			9.7	10	686	1,000	150	30
4	42	Slope	N.D.	"			11.5	20	407	1,000	153	30
4	5	McCone	Mont.	Power gener.			4.4	10	310	100	149	50
4	6	Slope	N.D.	" "			5.9	20	209	100	150	50
4	7	Hettinger	N.D.	" "			6.8	10	481	100	150	50
4	8	Hettinger	N.D.	" "			6.8	10	481	100	150	50
4	9	Billings	N.D.	" "			6.5	10	460	100	150	50
4	20	Sheridan	Wyo.	Export		10.0	10.0	40	177	-	150	-
4	1	Converse	Wyo.	"			10.0	35	202	-	150	-
4	21	Sheridan	Wyo.				10.0	40	177	-	150	-
4	22	Johnson	Wyo.	"			10.0	130	55	-	150	-
4	23	Johnson	Wyo.	"			10.0	130	55	-	150	-

Table 2 (Cont'd)

Map no.	Map ref. no.	County	State	Use	Production Millions tons per year 1980	1985	2000	Seam thick- ness (feet)	Acres disturbed by mining (yearly) 2000[1]	Acres covered by plant site	Acres devoted to mine facility	Acres covered by reservoir
				EXTENSIVE DEVELOPMENT FORECAST (Map 4)								
4	24	Sheridan	Wyo.	Export			10.0	40	177	-	150	-
4	37	Powder River	Mont.	"		10.0	10.0	35	202	-	150	-
4	38	Powder River	Mont.	"			10.0	35	202	-	150	-
4	39	Powder River	Mont.	"			10.0	35	202	-	150	-
4	40	Powder River	Mont.	"			10.0	35	202	-	150	-
4	41	Powder River	Mont.	"			10.0	35	202	-	150	-
4	42	Powder River	Mont.	"			10.0	35	202	-	150	-
4	43	Powder River	Mont.	"			10.0	35	202	-	150	-
4	44	Custer	Mont.	"			10.0	10	707	-	150	-
4	45	Custer	Mont.	"			10.0	10	707	-	150	-
4	46	Custer	Mont.	"			10.0	10	707	-	150	-
4	47	Slope	N.D.	"		4.0	10.0	20	353 (Yr.1980-142)	-	150 (Yr.1980-149)	-

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[1] Where figures for 1980 differ from year 2000, acres disturbed for 1980 are also shown.

Table 3.--Surface and subsurface (mineral estate) ownership by portions of states within the NGPRP study area

State	Unit	Total Area	Subtotal Non-Fed. State, Cnty & Private	1/ State	2/ BIA	Private County Municipal	3/ Subtotal Federal	4/ BRL	5/ Nat'l Park System	6/ Dept. of Defense		7/ BSF&W	8/ Bur. of Recl.	9/ ARS	10/ BIA	11/ Nat'l Forest Service
										Corps of Engineers	Military					
Montana	Surface Acres	34,616,448	28,745,673	1,996,245	2,863,043	23,886,385	5,870,775	4,050,982	4,012	471,601		* 631,363	18,766	55,238	87,996	550,817
	%	100	83.0	5.8	8.2	69.0	17.0	11.7	--	1.4		1.8	--	.2	.3	1.6
	Subsurface Acres	34,616,448	23,206,669	1,996,245	2,750,341	18,460,083	11,409,779	9,703,474	4,012	346,619		618,831	10,662	55,228	87,996	582,957
	%	100	67.0	5.8	7.9	53.3	33.0	28.0	--	1.0		1.8	--	.2	.3	1.7
North Dakota	Surface Acres	26,656,640	24,713,264	667,149	723,475	23,322,640	1,943,376	67,145	69,711	514,038	5,370	215,899	30,837	1,119	4,012	1,035,245
	%	100	92.7	2.5	2.7	87.5	7.3	.3	.3	1.9	--	.8	.1	--	--	3.9
	Subsurface Acres	26,656,640	21,249,957	667,149	1,015,790	19,567,018	5,406,683	4,202,982	69,631	18,088	--	160,591	11,215	1,119	4,012	939,045
	%	100	79.7	2.5	3.8	73.4	20.3	15.8	.3	--	--	.6	--	--	--	3.6
South Dakota	Surface Acres	11,671,680	11,023,855	690,29	1,942,170	8,391,38	647,825	220,405	--	121,824	5,843		29,166	360	6,402	263,820
	%	100	94.4	5.9	16.6	71.9	5.6	1.9	--	1.0	.1		.2	--	.1	2.3
	Subsurface Acres	11,671,680	10,263,291	1,505,01	2,099,625	6,653,651	1,408,389	1,121,125	--	--	--		19,423	360	6,407	261,074
	%	100	87.9	12.9	18.0	57.0	12.1	9.6	--	--	--		.2	--	.1	2.2
Wyoming	Surface Acres	18,584,320	14,330,234	1,602,93		12,727,29	4,254,086	2,656,354	1,347		21	1,240	48,401			1,546,723
	%	100	77.1	8.6		68.5	22.9	14.3	--		--	--	.3			8.3
	Subsurface Acres	18,584,320	10,672,552	1,626,00		9,048,470	7,911,768	6,337,278	1,347		--	1,240	25,180			1,546,723
	%	100	57.4	8.7		48.7	42.6	34.1	--		--	--	.2			8.3
Total NGPRP Area	Surface Acres	91,529,088	78,813,026	4,956,62	5,528,688	68,327,710	12,716,062	6,994,886	75,070	1,107,463	11,236	* 848,502	127,170	56,717	98,415	3,396,605
	%	100	86.1	5.4		74.7	13.9	7.6	.1	1.2	--	1.0	.2	--	.1	3.7
	Subsurface Acres	91,529,088	65,392,469	5,792,49	5,865,756	53,734,222	26,136,619	21,364,859	74,990	364,707		280,662	66,480	56,707	98,415	3,329,799
	%	100	71.4	6.3	6.4	58.7	28.6	23.4	.1	.4		.9	.1	--	.1	3.6

* 533,887 acres jointly administered by Bureau of Land Management

Table 3 (Cont'd)

Footnotes:

1/ State data (mineral ownership estimated for Montana and North Dakota)

a. Letter of September 27, 1973, J. D. Brunk, Executive Secretary, Department of Economic Planning and Development, Wyoming.

b. Letter of September 27, 1973, Jack Neckels, Director, North Dakota State Planning Division, North Dakota.

c. Letter of September 12, 1973, Arthur G. Wilner, Natural Resource Planner, State Planning Bureau, South Dakota.

d. Letter of September 11, 1973, Ted Clack, Program Coordinator, Human Resources Team, Montana Energy Advisory Council, Montana.

e. State of South Dakota, Department of School and Public Lands, South Dakota's Mineral Acres and How we Leave them for Oil and Gas, Bernard Linn, Commissioner, Pierre, South Dakota 57501.

2/ Acres of land owned by the Indians, the title of which is held in trust by the U.S. Government.
Letter of September 14, 1973, Wayne E. Stephens, Director Planning Support Group, Bureau of Indian Affairs, USDI, Billings, Montana.

3/ BLM unpublished data (mineral estate)

Compiled by: Bureau of Land Management, Montana State Office, Billings, Montana.

4/ BLM data compiled by: Bureau of Land Management, Montana State Office, Billings, Montana; and Bureau of Land Management, Wyoming State Office, Cheyenne, Wyoming.

5/ National Park Service Data. Letter of August 3, 1973, Ken Krabbenhoft, National Park Service, USDI, Omaha, Nebraska.

6/ Department of the Army, Corps of Engineers data. Letter of September 10, 1973, Gus J. Karabatsos, Chief, Planning Division, Missouri River Basin Division, Corps of Engineers, Department of the Army, Omaha, Nebraska.

7/ Bureau of Sport Fisheries and Wildlife data. Letter of August 31, 1973, Daniel V. Stiles, Chief, Branch of Wildlife Management, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, USDI, Washington, D.C. (588,887 acres jointly administered by BLM.)

8/ Bureau of Reclamation data. Letter of August 15, 1973, Russel W. Faus, Acting Regional Director, Bureau of Reclamation, Billings, Montana. Letter of September 5, 1973, H. H. Kelsch, Acting Assistant to Regional Director, Bureau of Reclamation, Billings, Montana.

9/ Agricultural Research Service data. Letter of September 12, 1973, Ralson R. Rhodes, Director, Agricultural Research Service, Hyattsville, Maryland.

10/ Acres of land owned by the Indians, the title of which is held in trust by the U.S. Government. Letter of September 14, 1973, Wayne E. Stephens, Director, Planning Support Group, Bureau of Indian Affairs, USDI, Billings, Montana.

11/ Forest Service data. Memorandum of October 5, 1973, William Holman, Forest Service, Region 1, USDA, Missoula, Montana.

GLOSSARY

Aerie	The nest of a bird of prey.
ARS	Agricultural Research Service, USDA.
Alienation	As used in this report, relates to the separation of ownership between the surface and subsurface estates.
Bentonite	It is any of numerous variously colored clay deposits, containing montmorillonite as the essential mineral, and characterized by the ability to swell when moistened and shrink when dried.
Biogeocoenosis	The aggregate of all interacting organisms and physical factors existing together in a particular habitat.
BIA	Bureau of Indian Affairs, USDI.
Bur. of Recl.	Bureau of Reclamation, USDI.
BSF&W	Bureau of Sport Fisheries and Widlife, USDI.
Chlorinated pesticide	A chlorinated hydrocarbon pesticide, many of which decompose very slowly and are lethal to wildlife in low concentrations. Examples are DDT, dieldrin, heptachlor, chlordane, and Mirex.
Climax	A community of organisms together with physical factors, such as the soil and climate, that interact in a dynamic equilibrium over time.
Commercial forest land	Land suitable and available for the production of crops of industrial wood at a rate of at least 20 cubic feet per acre per year, under management.
Coniferous forest biome	Biotic communities composed of all the plants and animals of an area, dominated throughout its entire range by coniferous trees and having a constant growth form of dominance and a similar ecological structure throughout.
Continuum	The occurrence of populations of organisms along a gradient, forming a distribution pattern of intergrading populations.

Deciduous forest biome	Biotic communities composed of all the plants and animals of an area, dominated throughout its entire range by deciduous trees and having a constant growth of dominance and a similar ecological structure throughout.
Demographic	Statistical data pertaining to people and populations.
Disclimax	An enduring climax community altered by disturbance, such as by grazing.
Dominant	A species or organism that manifests the primary influence and control upon the conditions of associated species.
Ecocline	A gradation in the adaptations of a community of organisms along an environmental gradient, lacking definite boundaries.
Ecosystem	A natural integrated system of all the biotic and abiotic factors of the environment; a natural organization of living and physical components in a geographical area having common and interacting transformations, circulation, and accumulation of matter and energy flow.
Ecotone	(Ponderosa pine ecotone) - open ponderosa forest of the study area with predominantly grass understory. The ecotone is the transition area between the pine forests and the grasslands.
Edge effect	A tendency for increased variety and density of both plants and animals where two or more plant communities meet. The transition zone is called an ecotone, and often animals specific to each of the two separate communities and specific to the ecotone are all present in the "edge" areas.
Endangered species	Species considered threatened with extinction (by the Secretary of the Interior), and whose names have been published in the Federal Register in accordance with the Endangered Species Conservation Act of 1969 (83 Stat. 275).
Epizootic	Prevalent temporarily among animals; e.g., an epizootic disease.

Exotic game bird	A game bird introduced from one part of the world to another, with the general intention of creating better hunting opportunities or filling an ecological niche created by accidental or intentional introduction of exotic plants, as in agriculture. Most exotic game bird introductions are unsuccessful, but the ring-necked pheasant, Hungarian partridge, and chukar partridge are notable exceptions.
Fee patent	A document issued by the federal Government for conveyance of title to public lands. The patents may be issued for the surface and/or subsurface.
Growing stock volume	The net volume in cubic feet of growing stock trees 5.0 inches diameter breast height and over from a 1-foot stump to a minimum 4.0-inch top diameter outside bark of the central stem.
Habitat	The place where a species lives. The habitat includes other organisms and the abiotic environment. In this report, habitat is subjectively classified as high, medium, or low quality habitat, depending on how well the area contributes to the life needs of a species, and the population density it can support. Additionally, an area is considered a species' habitat if individuals of the species could live there but don't. Key habitat is a specific type of place, the lack of which controls the species' population. An example is a small amount of suitable big game winter range available to a population in relation to a large amount of summer range.
NFS	National Forest System, Forest Service, USDA.
NPS	National Park Service, USDI.
NRL	National resource lands. Those lands administered by the Bureau of Land Management.
Necrosis	Death of a particular area of tissue.
Primary wood-using industry	An industry using roundwood as raw material.
Passerine birds	Perching birds, of the order Passeriformes; includes crows, sparrows, finches, thrushes, warblers, swallows, larks, and several others.

Population	All animals of a single species that occur in a given area.
Raptor	A bird of prey belonging to the former order of Raptores, which includes the eagles, hawks, kites, falcons, ospreys, vultures, and owls.
Riparian	Of or on a riverbank or near a body of water.
Rehabilitation potential	The capability of returning the land resource to its former productivity and physical stability.
Rehabilitation response unit	An area of land which can be identified as having specific precipitation, soil, and vegetation conditions, and which can be expected to respond in a predictable degree to given rehabilitation treatments.
Roundwood products	Products such as sawlogs, bolts, or other round sections cut from trees for industrial or consumer uses.
Secondary succession	The succession which takes place following the destruction of part or all of the vegetation in a community.

Soil terms See footnote 1/.

Aeric
Arbiborolls
Argialbolls
Argiaquic
Argiborolls
Arguistolls
Aridic
Aridisols
Association
Boralfic
Borollic
Calciaquolls
Calciborolls
Calciorthids
Cryoborolls
Cumulic
Entic
Entroboralfs
Eptic
Glossic
Halaquolls
Haplargids
Haploborolls
Haplustollic
Haplustolls
Leptic
Lithic
Natrargids
Natriborolls
Pachic
Pacnic
Paleargidis
Paralithic
Torrifluvents
Torriorthents
Torripsamments
Udic
Udorthentic
Ustertic
Ustic
Ustipsamments
Ustochrepts
Ustollic
Ustorthents
Vertic

1/ Because of the extreme complexity in defining these terms, the reader is referred to the unedited text of the "SOIL TAXONOMY" of the National Cooperative Soil Survey, December 1970; or to soil survey personnel in various agencies engaged in soil surveying activities.

Status - undetermined species	A species or subspecies that has been suggested as possibly threatened with extinction, but about which there is not enough information to determine its status.
Subclimax	A subfinal stage in succession, in which further development to the climax is inhibited because of the influence of some factor such as grazing, fire, or climate.
Subdominant	A species of organism that is associated with dominants, but which influence conditions in a community to a much less extent than the dominant.
Succession	The normal replacement of one kind of organism by another kind in response to changing physical, chemical, and biological conditions on a site.
Subsurface estate	Generally refers to those minerals which lie below the surface estate.
Surface estate	Ordinarily signifies a superficial part of the land, that being the surface. When employed in connection with mining, it usually means that part of the earth or geologic section lying over the minerals in question, unless the contract or conveyance otherwise defines it. Thus, where the surface is granted to one and the underlying coal to another, the "surface" includes the soils and waters which lie above and are superincumbent on the coal.
Threatened species	A species or subspecies that is so few in numbers or so threatened by present circumstances as to be in danger of extinction.
Timber products	Roundwood products and plant byproducts, and may include products cut from growing stock, from cull trees, from dead salvable trees, and from trees on noncommercial forest land.
Upland game	Birds or small mammals designated by state laws as game animals, which are generally associated more with uplands rather than with water bodies or wet areas.
Varmints	Birds and small mammals generally not protected by law and considered pests to agriculture.

Discussion draft
March 1974

IMPACTS OF SURFACE MINING ON SOILS

I. INTRODUCTION

The unique set of biotic, chemical, and physical properties that constitute a given kind of soil-plant system will be destroyed by surface mining. It cannot be preserved intact. Although the A and B horizons of the natural soil are stockpiled and spread back over the graded spoil after mining, several vital links in the set of interacting factors are broken.

Soil structure will be altered drastically. The natural network of pores and cracks that determine the distribution of percolating water, as well as the distribution of roots and air in the soil profile, will be entirely rearranged. If the A and B horizons are stockpiled and spread over the graded spoil, too much compaction will reduce pore space and make the soil relatively impervious to water, roots, and even air. Too little compaction may leave the soil too porous, and thus more droughty than necessary. The proper degree of compaction for the most favorable final soil will depend on the kind of soil. For most natural soils that have dark colored A horizons more than 3 or 4 inches thick, the most favorable final soil would have this material at the surface. Stockpiling of A and B horizons separately would be necessary for this final soil.

The soil micro-organisms, concentrated in the A horizon, are vital to both the chemical and physical properties of the natural soil. Only by special handling of the material from the A horizons can some of these micro-organisms be preserved to inoculate the final soil after mining and shaping.

Chemical properties of the natural soil will be altered significantly, especially if A and B horizons have different levels of pH and exchangeable bases and are not handled separately. Many soils of the study area have high levels of calcium carbonate in the B horizons. For many of these soils, mixing of the A and B horizons will result in soils with such high carbonate levels that the choice of adapted plants will be limited. For most such soils, special handling of the A horizons will minimize this problem.

Salinity is so high in some of the natural soils that adapted plants are severely limited. It may be desirable in the case of such soils to bury the entire soil profile, and leave at the surface relatively favorable nonsaline materials from selected geologic strata. Detailed site studies, including both soil surveys and studies of the geologic section are needed to determine the kind of grading that would produce the most favorable final soil. If deep nonsaline soils exist near the saline soil, a portion of the stockpiled A and B horizons from these soils might be used.

The B horizons of some soils in the study area are heavy, plastic clays. When this material is moist or wet, it is very sticky and difficult to spread. When it dries, it is very hard and difficult to pulverize or till. Separate handling of the A horizons of such soils, typically lower in clay, is indicated. In other soils, the lower subsoil is very sandy or gravelly. Mixing of this material with material from the A and upper B horizons would lower its quality.

Many soils in the study area are shallow to shale or other bedrock. On these soils the rooting depth of plants is limited by the bedrock, and, as a result, the soils are droughty and only plant species suited to dry sites grow naturally. It would be difficult to reconstruct a soil after mining with such a limited available water capacity as that existing before mining. Spreading of materials from the A and thin B horizons over materials from selected geologic strata will result in a final soil that is deeper and less droughty than the natural soil at the site before mining.

Detailed site study. Before mining begins, it is essential that detailed studies of the prospective site be conducted. Such studies should include as a minimum (1) inventories of the kind and abundance of plant species, (2) surveys of the existing runoff pattern and natural waterways, and estimates of volumes of runoff and erosion in the current use, (3) detailed soil surveys, and (4) detailed study of the geologic strata above the coal.

Through such studies, any sensitive local ecosystems will be determined and soil hazards and potentials will be identified. When this information is available, alternatives can be developed for stockpiling and final grading so that the final soil and landform will be most suitable for future use. In making these determinations, a careful evaluation must be made of the onsite and offsite water management objectives for each area; otherwise, severe onsite damage in the form of accelerated erosion, mass failures, lower productivity may occur along with such offsite damage as flooding and stream channel degradation. Where firm commitments have been established for a specific use after mining, plans can be developed so that soil and other aspects of the site may be most favorable for that use. For much of the area, it may be most logical to construct the best possible soil and landform from the standpoint of growing plants. If this were done, future generations would have the widest possible range in options in use of the land. If they should find it necessary or desirable to use the land intensively for cultivated crops, that option would be open to them because someone had the foresight not to bury and thus forever remove from potential usage the best suited materials.

Sediment. Surface mining will result in land that is denuded of vegetative cover and subject to erosion. The resulting erosion will be greater than that which occurred on the natural soils that existed before mining. Studies in Eastern United States indicate that erosion of unvegetated mined land occurs at rates of 100 to 400 tons per acre per year.

It is likely that the erosion of mined land in the Northern Great Plains would be less than in the East, because rainfall and runoff are less, and because of the larger extent of concave landforms that would result from mining the thick coal seams of the Plains. However, erosion will still be a serious problem and one which must be considered in plans to minimize undesirable impacts of surface mining.

Three general kinds of practices can be used to minimize erosion:

1. Diversion of runoff from slopes above the area of mining. Such runoff would be likely to cause extensive scouring and gullying of the exposed soil materials. Properly constructed and vegetated waterways around the edges of the area to be mined will prevent erosion due to such runoff.

2. Minimizing the length of time that the spoil materials and stockpiled A and B horizons are bare of vegetation. Plans should provide that the spoil be leveled and the stockpiled soil spread as soon as possible after mining. Interim seeding of ungraded materials, although an added expense, affords protection before final grading. Irrigation may be needed to establish vegetation to protect against erosion in a minimum length of time.

3. Collection of runoff from mined land in specially designed basins, and holding the runoff in the basins for a sufficient length of time for most of the sediment to settle out.

Although the total acreage likely to be surface mined, even in the extensive development scenario, is not a large percentage of the area of large watersheds, sediment from mined land may have a significant impact on the quality of local streams. Generally, the degree of impact will be less in the major rivers of the region.

Installation of the practices listed above will materially reduce the impact of mining on both perennial and intermittent streams, and will substantially reduce the degree of siltation in reservoirs in the region. Carefully conducted studies of prospective sites before mining are essential for developing the most suitable sediment control alternatives.

Impact on soil potentials. Although surface mining will destroy the natural soils, and, without proper reclamation, will severely reduce the productivity of the mined land for farming and ranching, the total impact of mining on agricultural production is likely to be low. The proportion of land suited for irrigated crops, dryland crops, and rangeland that is likely to be mined is small, relative to the total acreage of land suitable for these uses.

Indepth analyses were made of projected mining activities in four study areas where much of the surface mining is projected (Mercer and Oliver Counties, North Dakota; Rosebud County, Montana; Big Horn County, Montana; and Campbell County, Wyoming). The acreage of soils in each county suited for irrigated crops, dryland crops, and rangeland was determined by the offices of the Soil Conservation Service in each state. These acreages are given in the following table:

Table 1.--Acreage of soils suited for irrigated crops, dryland crops, and rangeland in indicated counties.

County	Irrigated Crops Acres	Dryland Crops Acres	Range Acres
Mercer and Oliver, North Dakota	244,000 (22%) 1/	720,000 (64%)	1,050,000 (94%)
Big Horn, Montana	400,000 (12%)	1,400,000 (44%)	2,900,000 (90%)
Rosebud, Montana	200,000 (6%)	500,000 (16%)	2,700,000 (84%)
Campbell, Wyoming	440,000 (15%)	900,000 (31%)	2,500,000 (86%)

1/ Percent of total area of the county(s).

II. ASSUMPTIONS

Assuming that the proportion of the areas to be surface mined that is suited for irrigated and dryland crops and range is the same as the proportion that is suited in the county as a whole, the number of acres in each suitability category for the land to be surface mined in each of three scenarios was estimated. The scenarios are defined elsewhere in this report.

Additional assumptions used in developing these estimates are:

1. Five years are required for restoration of mined land for irrigated or dryland crops, and 10 years are required for restoration of range.

2. The suitability ratings of soils are made irrespective of current uses of the soils, and are made independently for each of the uses. Soils suited for irrigated cropland are also suited for dryland crops and range, but not vice versa.

3. Availability of quality water for irrigation is assumed.

4. Only mined land will be returned to the uses discussed. Land used for facilities, roads, residential developments, etc., is considered permanently removed from such uses.

5. On the average, the productivity of land for irrigated crops or dryland crops will be less than that of the natural soils before mining. Loss of productive capacity will depend on the kind of soil, and will range mostly from one-third to one-tenth of that of the natural soil. However, as pointed out previously, for some of the soils, productive capacity for the indicated uses will be greater after mining than before mining if proper reclamation practices are followed.

III. RESULTS AND DISCUSSION

The following discussion of the impact of mining on the productive capacity of soils is presented according to the surface mining scenarios:

Base Forecast

By 2000 less than 0.2 percent of the productive capacity for farm and ranch products of Campbell, Big Horn, and Rosebud Counties will be lost because of surface mining. About two-thirds of the mined land will have been rehabilitated to a level 10 to 20 percent lower in productive capacity than that existing before mining. In Mercer and Oliver Counties, about 1.5 percent of the land suited for each of the uses will have been mined, but as a result of reclamation only about 0.5 percent of the productive capacity for irrigated and dryland crops and about 1.2 percent of the productive capacity of the county for rangeland will have been lost due to mining.

For the entire Northern Great Plains region, the net loss in capacity for farm and ranch production will be very minor.

Most Probable Forecast

At this level of mining the impact on the productive capacity of the five counties will be about the same by 1985 as that discussed above for the Base Forecast in 2000. By 2000, a loss of 0.2 to 0.5 percent in productive capacity will result in Campbell, Big Horn, and Rosebud Counties. Because of the thinner coal seams and larger acreages affected in Mercer and Oliver Counties, about 1.5 percent of the capacity for irrigated and dryland crops will be lost by 2000, and about 2.0 percent of the productive capacity for rangeland.

Extensive Development Forecast

By 2000 a loss of 0.5 to 1.0 percent of the productive capacity of the soils of Campbell, Big Horn, and Rosebud Counties will have occurred due to surface mining. Fifteen hundred to 3,000 acres per county that are suited to irrigated cropland, and 4,500 to 7,000 acres per county that are suited to dryland crops, will have been reclaimed and will have a productive capacity 10 to 20 percent less than the original soils had. In these counties about 1.0 percent of the rangeland will be permanently removed from production because of mining facilities, roads, and other developments associated with the increased mining activity.

In Mercer and Oliver Counties, about 2.5 percent of the productive capacity for irrigated and dryland crops, and 2.0 percent of that for range will have been lost by 2000. Nearly 12,000 acres suited for dryland crops will be removed from production, and 24,000 acres of soils suited for dryland crops will be reclaimed. It is estimated that the productive capacity on the reclaimed acreage will average 30 percent less than the natural soil, at least for the first few decades following mining.

For the region, the loss in productive capacity from farms and ranches as a result of mining will be well under 0.5 percent by 2000 for the Extensive Development Forecast. The most effective reclamation will hold this impact to a minimum.

Impact of associated urban development. Substantial increases in population are likely to occur with increased levels of surface mining in the region. However, the amount of land needed for such developments is a very small proportion of the total area, and the resulting reduction in the productive capacity of farms and ranches is likely to be small.

Impacts of urban development on the productive capacity of agriculture can be minimized by zoning or adoption of other policies that will prevent such development on soils currently irrigated or soils uniquely suited for irrigation or for specific dryland crops. The identification of such soils through detailed soil surveys is an essential requirement for such land use controls.

Numerous soil hazards for urban development exist in the region. Examples are soils with high shrink-swell potentials or with the tendency to slip on slopes, both of which cause failures in foundations and basement walls; soils with high frost action that result in failures and expensive maintenance of pavements, carports, sidewalks, and parking lots; soils with high seasonal water tables that cause wet basements and soggy lawns if proper drainage is not provided; and soils that are so impervious or naturally wet that individual septic tank systems fail. These problems can be identified ahead of development by detailed soil surveys of prospective sites.

Discussion Draft
March 1974

IMPACTS OF COAL DEVELOPMENT ON VEGETATION

I. INTRODUCTION

Mining, per se, and associated plants and facilitating structures will destroy the present vegetation. Because a large majority of the vegetated lands supports grazing by the livestock industry, this report considers impacts that would result to vegetation, livestock production, and grazing values on both the sample counties and a regional basis.

II. ADDITIONAL ASSUMPTIONS

1. All land which is in range use at time of mining will be returned to range use following rehabilitation. All mined land will be returned to range use within 10 years after mining.
2. Land restored to range use following mining and rehabilitation will have the same stocking rate as before mining.
3. Vegetation on land used for mine buildings and facilities may not be totally destroyed, but will be withdrawn from grazing use throughout the time frame stated.
4. Land within fenced railroad, highway, pipeline, or townsite rights of way will be permanently withdrawn from livestock grazing, although vegetation may not be destroyed on portions of it.
5. Land within unfenced transmission corridors--either pipelines or powerlines--will be withdrawn from grazing only temporarily

during and immediately following construction. Except for maintained roadways or trails needed for servicing, the area will be returned to grazing use following any needed revegetation.

6. All grazing land is considered to have a stocking rate of 3 acres per animal unit month (AUM). This stocking rate will also apply to mined areas which have been rehabilitated and returned to range use.

7. The value of grazing on all native grazing lands is considered to be $6.00 per AUM. This is the equivalent of $2.00 per acre per year. This rate will continue through year 2000, and will also apply to mined lands rehabilitated and restored to range use.

8. Of all land disturbed by mining and attendant facilities, the following percentages are rangeland:

Campbell County, Wyoming	100	percent
Rosebud County, Montana	80	"
Big Horn County, Montana...........	80	"
Mercer County, North Dakota) Oliver County, North Dakota)	60	"
Region as a whole	70	"

III. RESULTS

Impact of Surface Mining on Vegetation

On all areas actually involved in mine excavation or piling of mine overburden material, it is obvious that the present vegetation would be completely destroyed. Vegetation would also be destroyed on all areas occupied by generating plants, mine buildings, roads, railroads, reservoirs, storage yards, and other facilitating structures which totally cover the soil surface.

Based upon studies and careful field observation of numerous areas within the NGPRP area which had been denuded of vegetation, limited natural revegetation could be expected with cessation of mining operations. This would be limited initially to aggressive annual and short-lived perennial plant species. At best, only a very sparse, spotty stand of plants could be expected to occur naturally. Much erosion and site deterioration would be expected to occur during the many years which would be required for satisfactory revegetation of mined lands through natural processes. Restoration of a plant cover comparable with the pre-mining cover will require extensive rehabilitation of the site, including seeding and planting. This would be the only practical procedure for restoring adequate vegetation within an acceptable period of time.

In addition to areas on which vegetation would be totally destroyed by mining operations, plant cover on other areas would be affected less severely. Vegetation on land within fenced rights of way, but not actually occupied by railroad track beds, highways, aqueducts, or transmission towers, may be damaged during construction; but would not necessarily be destroyed. Plant cover on such areas could be relatively quickly restored following construction disturbance. In many instances, restoration by natural processes would be reasonably rapid if plant cover damage was not severe.

Vegetation on soils lying between haul roads, adjacent to plant sites and on intervening areas, may not be destroyed by construction or by mining. It may be damaged or altered, however, by excessive amounts of dust, fumes, chemicals, or lubricants involved in the operation of mining equipment and coal processing facilities.

Most of the natural plant communities of the NGPRP developed under conditions of grazing use. Vegetation on areas excluded from grazing, although not damaged by mining or facilitating processes, will likely develop composition characteristics unlike the natural plant community because of the elimination of grazing as an environmental factor. In addition, areas of vegetation withdrawn from grazing would most likely develop increased amounts of flammable litter and residue, and, thus, would represent an increased fire hazard.

Impact of Surface Mining on Livestock Production

The impact of projected surface mining on domestic livestock production within the Northern Great Plains resource area is quite insignificant when viewed from a regional, state, or county basis. Perhaps the most meaningful manner in which to assess the impact is in terms of actual animal units of livestock which would be displaced by projected mining at specific points in time, and the comparison of this number of animal units with the current total numbers in the same region, state, or county. For example, projections on the most extensive level of surface coal mining indicate a total of 223,852 acres of rangeland would be unavailable for grazing in year 2000. This includes natural grazing lands currently being mined, that which is in the process of rehabilitation following mining, and the acreage more or less permanently occupied by mine facilities, transmission lines, and other coal-related uses. At a rate of 3 acres per animal unit month, a total of 74,617 AUM's of grazing would be foregone. This is the equivalent of the grazing needs of 6,218 animal units on a yearlong basis. Statistical Reporting Service data on 1972 livestock numbers, converted to an animal unit basis, indicate a total of 3,178,410 animal units of cattle, calves, sheep, and lambs in the region. Therefore, the total animal units displaced by mining activities at the extensive forecast level in year 2000 is only 0.0019, less than 2/10 of 1 percent of present livestock numbers in the region. The value of the foregone grazing, at a rate of $6.00 per AUM, would total $447,704 in year 2000. (See Table 1 for livestock figures.)

Even within the four sample counties where mining is expected to be most concentrated, the number of animal units which would be displaced in the most extensive forecast by year 2000 is relatively small. It exceeds 1 percent of present numbers only in Campbell County, Wyoming and Rosebud County, Montana. The following table indicates the 1972 livestock numbers in animal units, the number of

Table 1.--Livestock on farms and ranches within NGPRP region, January 1, 1972 (in animal unit equivalents)

Wyoming Counties	Cattle & Calves	Sheep & Lambs	Total
*Campbell	63,450	24,200	87,650
Sheridan	71,550	8,440	79,990
Johnson	48,675	28,340	77,015
Natrona	48,375	42,900	91,275
Converse	61,950	23,820	85,770
Niobrara	51,600	9,000	60,600
Weston	42,150	3,480	45,630
Crook	55,500	12,600	68,100
Totals	443,250	152,780	596,030

Montana Counties	Cattle & Calves	Sheep & Lambs	Total
Daniels	15,825	1,300	17,125
Dawson	37,800	3,500	41,300
Garfield	60,450	18,400	78,850
McCone	33,000	4,700	37,700
Richland	43,650	4,400	48,050
Roosevelt	30,675	1,400	32,075
Sheridan	24,000	600	24,600
Valley	65,850	2,700	68,550
Golden Valley	21,975	2,000	23,975
Musselshell	28,200	3,000	31,200
*Big Horn	96,750	1,700	98,450
Treasure	23,850	560	24,410
Yellowstone	111,975	2,780	114,755
Carter	49,350	25,400	74,750
Custer	70,575	5,000	75,575
Fallon	34,725	1,900	36,625
Powder River	65,100	8,800	73,900
Prairie	32,625	1,300	33,925
*Rosebud	74,400	4,700	79,100
Wibaux	18,225	1,900	20,125
Totals	939,000	96,040	1,035,040

Table 1 (Cont'd)

North Dakota Counties	Cattle & Calves	Sheep & Lambs	Total
Burke	12,000	680	12,680
Divide	12,750	580	13,330
Mountrail	30,000	860	30,860
Renville	6,750	280	7,030
Ward	39,000	1,240	40,240
Williams	32,250	1,100	33,350
Bottineau	21,000	880	21,880
McHenry	56,250	880	57,130
Pierce	24,750	620	25,370
Dunn	71,250	760	72,010
McKenzie	76,500	1,140	77,640
McLean	51,750	980	52,730
*Mercer	48,000	400	48,400
*Oliver	27,750	520	28,270
Kidder	50,250	3,120	53,370
Sheridan	27,750	340	28,090
Adams	27,000	1,200	28,200
Billings	26,250	120	26,370
Bowman	24,750	5,800	30,550
Golden Valley	20,250	660	20,910
Hettinger	28,500	540	29,040
Slope	24,000	960	24,960
Stark	48,000	740	48,740
Burleigh	55,500	1,220	56,720
Emmons	53,250	240	53,490
Grant	57,750	1,260	59,010
Morton	81,750	1,120	82,870
Sioux	27,750	780	28,530
Totals	1,062,750	29,020	1,091,770

South Dakota Counties	Cattle & Calves	Sheep & Lambs	Total
Butte	41,250	36,900	78,150
Corson	51,000	3,580	54,580
Dewey	36,750	3,660	40,410
Harding	48,000	16,080	64,080
Perkins	66,750	12,340	79,090
Ziebach	31,500	3,960	35,460
Meade	93,000	10,800	103,800
Totals	368,250	87,320	455,570

Total-All Counties	2,813,250	365,160	3,178,410

*Sample Counties

AU's which would be displaced by the most extensive forecast level of mining in year 2000 and the percentage of the present AU's represented by the displaced AU's:

Area	Animal units January 1972	Animal units displaced	Percent of present AU's
Campbell County, Wyoming	87,650	950	1.08
Big Horn County, Montana	98,450	664	0.67
Rosebud County, Montana	79,100	938	1.18
Mercer County, No. Dakota)) Oliver County, No. Dakota)	76,670	598	0.78
Total four sample counties	341,870	3,150	0.92
Region total	3,178,410	6,218	0.19

The impact of mining would become much more severe on an individual livestock operating unit basis. A single surface mine, with its attendant facilities, could displace a significant portion or all of an operating unit. A large mine operation could significantly affect several adjacent livestock units. The impact in such cases could be extensive enough that the operating unit would cease to exist.

In the event that mining operations preempted livestock grazing from a portion of a livestock operating unit, the livestock producer would have several alternative actions to consider in adjusting to the loss of his grazing resource. Among alternatives are:

1. Sell or lease the remainder of the land, along with his livestock and equipment, and go out of the livestock business.

2. Sell a number of livestock, proportionate to the reduced forage available. This may reduce the operation to less than an economic unit.
3. Purchase or lease other grazing land to replace that involved in surface mining.
4. Purchase hay, pasturage, or other feed to compensate for loss of grazing land.
5. Increase the stocking rate on remaining grazing lands. This would present the hazard of overuse and resultant vegetation and soil losses on the remaining lands. (This alternative may not exist if grazing lands were federally owned and grazing was by permit or license specifying maximum numbers of livestock and/or period of grazing.)
6. Graze remaining lands for a longer period than is customary, to accomodate added grazing needs. Again, this presents the hazards of long-continued heavy grazing use to remaining grazing lands. If initial stocking rate and period of grazing was proper, the added grazing would result in site deterioration.
7. Convert a portion of remaining grazing land to cropland or improved and highly productive pastureland. (Opportunities for such conversions are limited by soil capabilities and available moisture.)
8. Change use of remaining land from grazing to some other use such as recreation, housing development, etc.

Value of Grazing

In the present study an animal unit month (AUM) of grazing is valued at $6.00. This rate is based primarily upon current rental values for grazing land. Grazing rates in effect at the time of this study ranged from a low of $4.00 per AUM to over $10.00. The price charged for grazing varies with changes in availability and demand for grazing lands, the current and projected price of livestock, and other costs of livestock production. After extensive study and review, it is believed that $6.00 per AUM is an acceptable average rate and is applied to grazing resources of the entire area of study (Table 2).

The actual value of grazing to an individual livestock operating unit depends upon a great many physical, environmental, economic, and social factors. The true value of any tract for grazing must be determined through on-the-ground evaluation of that tract by itself and in relation to the remainder of the livestock operating unit of which it is a part. Factors which should be considered include:

1. The kind, quality, and amount of forage produced.
2. The present and potential production of the tract.
3. Seasonal availability and usefulness of forage.
4. The kind(s) of animals for which the forage is best suited.
5. The accessibility as influenced by topography, stoniness, location, and adequacy of livestock water, etc.
6. The ownership, tenure, or terms of lease or grazing allotment.
7. How the specific tract relates to the remainder of the land in the livestock operating unit with respect to:

Legend for Table 2

In Table 2 and on the matrix forms developed for the analysis, the following items are employed:

Mined Ac.	Land which is currently being mined, plus that which has been mined but has not yet been fully restored to grazing use.
Facilities	Acreage occupied by gasification and generator plants, storage yards, and other facilities directly associated with surface mines, and which will be permanently withdrawn from grazing use.
Perm. Out.	Acreage involved in rights of way for railroads, highways, haul roads, transmission lines, aqueducts, reservoirs, etc., which is permanently withdrawn from grazing use.
Temp. Out.	Acreage within construction corridors. Vegetation may be partially destroyed and the area temporarily unavailable for grazing, but not permanently withdrawn.
AUM's Grazing	Animal unit months grazing value foregone at this date. An animal unit month is the amount of natural forage required to support one animal unit of livestock (or wildlife) for 1 month. An animal unit (AU) is one mature cow (approximately 1,000 pounds) or its equivalent of other animals (for example, 5 sheep = 1 AU).
Total AU/YL	The total animal units on a yearlong basis which would be displaced by projected mining activities at this date.
Grazing Value	Annual value of grazing foregone @ $6.00 per animal unit month.
Rehab.	Acreage which has been mined and rehabilitated and returned to grazing use.
Net Out of Prod.	This is the total acreage currently withdrawn from grazing use. It includes areas being mined, under rehabilitation, occupied by facilities, that which is permanently withdrawn from grazing, that temporarily withdrawn--as in construction corridors. It does not include acreage mined but now returned to grazing.

Table 2.--Summary of impact analyses by coal development forecasts and stated time frames in sample counties and a regional basis

Campbell County, Wyoming 100% grazing land affected.

Base Forecast

Item	1980	1985	2000
Mined Ac.	448	2,032	8,126
Facilities Ac.	599	599	1,047
Rehabilitated Ac.	--	-50	-4,404
Net Out of Production Ac.	1,045	2,580	4,775
AUM's Grazing	348	860	1,592
Total AU/YL	29	72	133
Grazing Value	$2,090	$5,184	$9,550

Most Probable

Mined	509	2,543	12,670
Facilities, etc.	749	2,229	2,528
Rehabilitated	--	-65	-5,984
Net out of Prod.	1,260	4,705	9,215
AUMs Grazing	420	1,568	3,072
Total AU/YL	35	131	256
Grazing Value	$2,520	$9,410	$18,430

Extensive

Mined Ac.	509	3,511	27,665
Facilities	749	6,069	9,650
Perm. Out.	--	--	2,386
Temp. Out	--	--	8,506
Rehabilitated	--	-90	-14,000
Net Out of Prod.	1,257	9,490	34,207
AUMs Grazing	419	3,163	11,402
Total AU/YL	35	264	950
Grazing Value	$2,514	$18,980	$68,414

Table 2 (Cont'd)

Bighorn County, Montana

Acres shown are net grazing land. (basis of 80% mined area)

Base Forecast

Item	1980	1985	2000
Mined Ac.	260	1,015	3,945
Facilities	240	240	840
Rehabilitated	--	-30	-2,020
Net Out of Prod.	500	1,225	2,765
AUMs Grazing	167	408	922
Total AU/YL	14	34	77
Grazing Value	$1,000	$2,450	$5,530

Most Probable

Mined	300	1,370	7,370
Facilities	360	2,250	3,670
Rehab.	--	-35	-3,405
Net Out of Prod.	660	3,585	7,635
AUMs Grazing	220	1,195	2,545
Total AU/YL	18	100	212
Grazing Value	$1,320	$7,170	$15,270

Extensive

Mined Ac.	375	1,900	11,900
Facilities	1,305	3,315	10,175
Perm. Out.	--	--	2,165
Temp. Out	--	--	4,920
Rehabilitated	--	-45	-5,270
Net out of Prod.	1,680	5,170	23,890
AUMs Grazing	560	1,723	7,963
Total AU/YL	47	144	664
Grazing Value	$3,360	$10,340	$47,780

Table 2 (Cont'd)

Rosebud County, Montana

Acres shown are net grazing land. (Basis of 80% mined area)

Item	1980	1985	2000
Base Forecast			
Mined Ac.	1,805	3,915	11,930
Facilities	240	240	480
Rehabilitated	--	-125	-6,710
Net Out of Prod.	2,045	4,030	5,700
AUM Grazing	682	1,343	1,900
AU/YL Total	57	112	158
Grazing Value	$4,090	$8,060	$11,400
Most Probable			
Mined	1,805	4,340	18,750
Facilitating	240	1,305	2,610
Rehabilitated	--	-140	-9,280
Net Out of Prod.	2,045	5,505	12,080
AUM Grazing	682	1,835	4,027
Total AU/YL	57	153	336
Grazing Value	$4,090	$11,010	$24,160
Extensive			
Mined Ac.	2,030	6,290	36,135
Facilities	1,185	4,260	4,855
Perm. Out.	--	--	3,445
Temp. Out.	--	--	5,765
Rehabilitated	--	-200	-16,440
Net Out of Prod.	3,215	10,350	33,760
AUMs Grazing	1,072	3,450	11,253
Total AU/YL	89	288	938
Grazing Value	$6,430	$20,700	$67,520

Table 2 (Cont'd)

Oliver and Mercer Counties, North Dakota

Acres shown are net grazing land. (Based on 60% of mined area)

Base Forecast

Item	1980	1985	2000
Mined Ac.	1,970	3,600	9,960
Facilities	360	360	540
Rehabilitated	--	-750	-6,470
Net Out of Prod.	2,330	3,210	4,030
AUM Grazing	777	1,070	1,343
Total AU/YL	65	89	112
Grazing Value	$4,660	$6,420	$8,060

Most Probable

Mined Ac.	1,970	4,025	17,000
Facilitating	360	1,065	2,135
Rehabilitated	--	-800	-9,150
Net Out of Prod.	2,330	4,290	9,985
AUM Grazing	777	1,430	3,328
Total AU/YL	65	119	277
Grazing Value	$4,660	$8,580	$19,970

Extensive

Mined Ac.	2,815	8,265	34,645
Facilitating	1,775	2,480	4,320
Perm. Out.	--	--	100
Temp. Out.	--	--	685
Rehabilitated	--	-1,140	-18,205
Net Out of Prod.	4,590	9,605	21,545
AUMs Grazing	1,530	3,202	7,182
Total AU/YL	128	267	598
Grazing Value	$9,180	$19,210	$43,090

Table 2 (Cont'd)

Grazing Land Only

Summary - 4 Sample Counties Only

Does not include Regional outside sample counties

Base Forecast

Item	1980	1985	2000
Mined Ac.	4,483	10,562	33,961
Facilitating	1,439	1,439	2,907
Rehabilitated	--	-955	-19,608
Net Out of Prod.	5,922	11,046	17,260
AUMs Grazing	1,974	3,682	5,753
Total AU/YL	165	307	479
Grazing Value	$11,844	$22,092	$34,520

Most Probable

Mined Ac.	4,586	12,276	55,790
Facilitating	1,709	6,849	10,945
Rehabilitated	--	-1,040	-27,820
Net Out of Prod.	6,295	18,085	38,915
AUMs Grazing	2,098	6,028	12,972
Total AU/YL	175	502	1,081
Grazing Value	$12,590	$36,170	$77,830

Extensive

Acres Mined	5,728	19,966	110,345
Facilitating	5,014	16,124	29,000
Perm. Out	--	--	8,096
Temp. Out	--	--	19,876
Rehabilitated	--	-1,475	-53,915
Net out of Prod.	10,742	34,615	113,402
AUMs Grazing	3,581	11,538	37,800
Total AU/YL	298	962	3,150
Grazing Value	$21,484	$69,230	$226,804

Table 2 (Cont'd)

Regional - Does not include sample counties.

Does include some items which could not be identified with specific counties or states.

Acres are net grazing land (Based on 70% of mined area)

Item	1980	1985	2000
Base			
Mined Ac.	--	--	265
Facilitating	--	--	315
Rehabilitated	--	--	-90
Net Out of Prod.	0	0	490
AUMs Grazing	--	--	163
Total AU/YL	--	--	14
Grazing Value	--	--	$980
Most Probable			
Mined Ac.	75	675	14,520
Facilitating	105	1,760	8,085
Rehabilitated	--	--	-4,690
Net Out of Prod.	180	2,435	17,915
AUM Grazing	60	812	5,972
Total AU/YL	5	68	498
Grazing Value	$360	$4,870	35,830
Extensive			
Mined Ac.	1,115	6,575	47,015
Facilitating	2,480	5,065	16,460
Perm. Out.	--	--	9,745
Temp. Out.	--	--	51,825
Rehabilitated	--	--	-14,595
Net Out of Prod.	3,595	11,640	110,450
AUMs Grazing	1,198	3,880	36,817
Total AU/YL	100	323	3,068
Grazing Value	$7,190	$23,280	$220,900

Table 2 (Cont'd)

Regional - Summary from all Counties

Item	1980	1985	2000
	Base Forecast		
Mined Ac.	4,483	10,562	34,226
Facilitating	1,439	1,439	3,222
Rehabilitated	--	-955	-19,694
Net Out of Prod.	5,922	11,046	17,754
AUMs Grazing	1,974	3,682	5,918
Total AU/YL	165	307	493
Grazing Value	$11,844	$22,092	$35,508
	Most Probable		
Mined Ac.	4,659	12,953	70,310
Facilitating	1,814	8,609	19,028
Rehabilitated	--	-1,040	-32,509
Net Out of Prod.	6,473	20,522	56,829
AUMs Grazing	2,158	6,841	18,943
Total AU/YL	180	570	1,579
Grazing Value	12,946	41,044	113,658
	Extensive		
Mined Ac.	6,843	26,541	157,360
Facilitating	7,494	21,189	45,460
Perm.Out	--	--	17,841
Temp. Out	--	--	71,701
Rehabilitated	--	-1,475	-68,510
Net Out of Prod.	14,337	46,255	223,852
AUMs Grazing	4,779	15,418	74,617
Total AU/YL	398	1,285	6,218
Grazing Value	28,674	92,510	447,704

Table 2 (Cont'd)

Extensive Forecast for AD 2000

Mined to date = 157,360 acres
Occupied by Mining Facilities = 45,460
Permanently Excluded (rights of way, etc.) = 17,841
Temporarily Excluded (construction right of way) = 71,701
Total Rehabilitated and back in grazing = -68,510
Net Acres Out of Production = 223,852
AUM Grazing @ 3 ac/AUM = 74,617
Total Animal Units - Yearlong basis = 6,218
Grazing Value @ 6.00/AUM = $447,704

Total livestock in Region - 1973: 3,178,410 Animal Units

Animal Units displaced under Extensive forecast at year 2000 = 6,218 Animal Units

Percent of Total = $\frac{6,218}{3,178,410} = .0019563$

AUMs Grazing = Animal Unit Months grazing foregoneat this date.
Total AU/YL = Total animal unit equivalents displaced at this date.
Grazing Value = Annual value of foregone grazing @ 6.00 per AUM.
Rehab. = Acres formerly mined, but restored to grazing use.
Net Out of Prod. = Total acres not available for grazing on this date.
Note: Mined Ac. = Land actually mined - from time of mining until restored to grazing use.
Facilities = Plants, yards, etc. permanently withdrawn from grazing.
Perm. Out. = Rights of way for railroads, highways, road, transmission lines, etc. permanently withdrawn from grazing.
Temp. Out. = Construction corridors - temporarily depleted, but not permanently out of production.

Table 2 (Cont'd)

Livestock on Farms and Ranches - in Animal Unit Equivalents

	Cattle & Calves	Sheep	Total AUs
Campbell County, Wyoming	63,450	24,200	87,650
Bighorn County, Montana	96,750	1,700	98,450
Rosebud County, Montana	74,400	4,700	79,100
Mercer County, North Dakota)	75,750	920	76,670
Oliver County, North Dakota)			
Total - Four Sample Areas	310,350	31,520	341,870
Wyoming Portion of NGPRP	443,250	152,780	596,030
Montana Portion of NGPRP	939,000	96,040	1,035,040
North Dakota Portion of NGPRP	1,062,750	29,020	1,091,770
South Dakota Portion of NGPRP	368,250	87,320	455,570
Total for Region	2,813,250	365,160	3,178,410

Note: Data from Statistical Reporting Service. All 1971 data except for Wyoming which is 1973 data.

"All Cattle and Calves" data from SRS converted to animal units on the basis of .75 animal unit per head.

Five "Sheep and Lambs" considered to be one animal unit.

(a) Seasonal balance in forage supplies.

(b) Distance from other properties in operating unit, and ease with which animals may be moved from one portion of unit to another.

(c) The size of the tract--as it affects the economic status of the operating unit.

The value of an individual tract or acreage to a livestock operating unit is frequently not based upon the productivity of that tract, but upon the fact that the tract provides forage during a critical period of the year when no other forage is available. It may, therefore, be an essential link in the year-round livestock operation, although it produces a small amount of the year-round forage supply. (For example, the spring lambing range for a sheep unit or a subirrigated meadow which can be grazed when upland ranges are dry.)

An added "nuisance factor" affects grazing values when a portion of a livestock operating unit is diverted to a nongrazing use such as surface mining. The location of the development in relation to other lands and to livestock handling facilities is important. If, for example, a mining development was located at the outside edge of a large grazing unit, it may have little effect other than reducing acreage available for grazing. If, on the other hand, the mining development was located near the center of a livestock ranch, it could seriously interfere with movement of livestock, fencing and pasture arrangement, livestock water supplies and distribution, and animal performance.

Discussion draft
March 1974

IMPACTS OF COAL AND RELATED DEVELOPMENTS ON FISH AND WILDLIFE RESOURCES

I. INTRODUCTION

This report is based on data acquired by the subgroup through January 1974, which projects coal mine, power plant, and gasification plant development and estimated area populations through the year 2000 for the three development forecasts. In the Extensive Development Forecast for the year 2000, some data were provided by the Water Resource Work Group that projected railroads, highways, transmission lines, aqueducts and a reservoir. Other data were provided by the Socioeconomics Work Group. Conclusions are the opinions of subgroup members as to projections of what may occur.

Two conclusions of the subgroup warrant consideration: (1) with the probable exception of the peregrine falcon, no species will be exterminated from the study area under any forecast; (2) all game species which are currently hunted will be maintained on a regional basis as huntable populations. These conclusions are tentative. The analysis has considered only two changing conditions - land and people. No water developments and no changes in air quality have been considered. Of the land changes the subgroup considered only coal and closely related development. Those same areas subject to coal development under the three forecasts are also rich in oil, gas, and uranium. In or adjacent to the region are minable deposits of oil shale, trona, bentonite, soda ash, phosphate, and sand and gravel. Furthermore, additional industry is certain to locate near abundant raw minerals and energy.

The data the subgroup analyzed had three serious shortcomings -

1. No lead time was projected for development. Therefore the analyses do not consider effects occurring during plant construction periods, nor were effects of disturbance from exploration and site testing accounted for. For example,

activity during years of construction and development before plants come on line at the three time frames specifies will cause unaccountable disturbance.

2. No land was relegated to people or their needs. Large population increases will require much land just for the people to live on. Urban and suburban sprawl characteristically eliminates much productive bottomland and often results in loss of more bottomlands to flood protection works. On the prairie and in the desert the wet bottomlands and the brushy draws provide a vital "edge effect" where plant communities meet and provide the habitat requirements for a greater variety of wildlife species.

3. The period of analysis ends as most of the development begins - in the year 2000. This is a significant deficiency if future impacts are to be reviewed in perspective. For example, under the Extensive Development Scenario, 41 of the 75 mines, powerplants, and gasification plants projected for Montana and Wyoming do not start up until the year 2000. The habitat those developments would occupy and the acres of overburden stripped in one year is accounted for, but the environmental damage they would do in twenty years is not considered. Table 1 shows the difference in habitat lost in the years 2000 and 2020 in Montana and Wyoming, assuming a static production during those 20 years.

Table 1.--Comparison of Acres of Good and Medium Quality Wildlife Habitat Lost in the Year 2000 to the Year 2020 in Montana and Wyoming. All disturbed lands are assumed restored to pre-disturbance habitat capacity within 25 years.

Forecast	Base		Most Probable		Extensive	
Year	2000	2020	2000	2020	2000	2020
Deer	32,477	52,999	61,203	121,988	208,329	424,974
Antelope	25,343	39,829	43,343	84,710	143,112	292,242
Sage Grouse	23,896	32,096	50,111	79,871	139,326	279,814
Sharp-tailed Grouse	24,016	39,387	47,034	95,185	147,534	310,385
Hungarian Partridge	22,763	36,156	41,839	73,712	114,871	232,134
Ring-necked Pheasant	13,001	15,356	22,513	35,908	56,247	95,662
Turkey 1/	2,202	5,252	5,199	17,989	43,350	94,559
Waterfowl	32,347	52,652	62,957	123,488	211,031	432,542
Raptors	33,049	53,964	65,142	126,833	229,239	460,415

1/ Includes low-quality habitat.

II. IMPORTANT FINDINGS AND CONCLUSIONS

In the Base Forecast, by the year 2000, habitat of Merriam's wild turkey and several endangered species, notably the peregrine falcon, will have deteriorated to a level of serious concern throughout the region. Hunting for elk in central and western Montana and Wyoming and for sage grouse throughout the region will have seriously changed in character. In each of the four sample areas several species of endangered birds and mammals will have been significantly adversely affected. The human population of Campbell County, Wyoming, will have increased to levels disastrous to the American peregrine falcon and the black-footed ferret - each an endangered species which may inhabit the County. Also in Campbell County and Oliver and Mercer Counties, North Dakota, deer hunting will have been seriously affected.

Significant sage grouse habitat in Big Horn County, Montana, will have been destroyed. Deer habitat in Rosebud County and Oliver and Mercer Counties will have been lost in serious amounts. Regional and local populations of most other species will be little affected.

In the Most Probable Forecast, by year 2000, loss of habitat but mainly an influx of people will have had disastrous effects on some local populations of threatened species in the region.

Regional losses of good habitat now utilized by deer, antelope, sage grouse, and wild turkey will be of major concern to game managers and the public. Hunting for all big-game species and for sage grouse and ring-necked pheasant will have substantially changed from present conditions. Resident and non-resident big-game hunters will be subjected to more rigidly controlled hunts and moderately reduced bag limits. Non-resident hunting will be moderately reduced, and residents will pay proportionately more for individual hunting privileges.

Concentration of development and people will be particularly adverse to wildlife resources in Oliver and Mercer Counties, North Dakota, and Campbell County, Wyoming. Effects on endangered species here may be disastrous. Hunting for big game in the four sample areas will be quite changed from present conditions. Hunting for upland game and waterfowl and fishing in Oliver and Mercer Counties may be so changed from what sportsmen now enjoy that long-term residents will consider nearby outdoor opportunities ruined. In Big Horn County, Montana, small trout streams of the Big Horn Mountains and the renowned fishery of the Big Horn River below Yellowtail Dam will be subjected to excessive fishing pressure.

By 1985, in the Extensive Development Forecast, effects on fish and wildlife resources and their consumptive uses will be as adverse as they would be by the year 2000 in the Most Probable Forecast summarized above.

By the year 2000 deer, turkey, raptor, and endangered species habitat in the region will be noticeably affected. Hunting conditions for deer and sage grouse will have radically changed for the worse. Elk and other big game hunting in all of Montana and Wyoming, and the important related non-resident guiding and outfitting industry will be drastically changed. Fish and Game Departments of those states will either (1) increase tremendously the cost of resident hunting privileges, (2) cut their staffs and operations almost in half, or (3) become dependent on state general revenue funding.

Serious antelope, ring-necked pheasant, and waterfowl habitat losses will likely occur. Hunting for these species and for sharp-tailed grouse and forest grouse will be little affected by the projected development. Non-game wildlife, such as passerine birds, small mammals, reptiles, and amphibians will be affected. Their losses will be subtle, difficult to document or even understand, and the effects on them will probably last longer. Fishing pressures will skyrocket but shifting emphasis to less utilized species will mollify excessive local pressures.

In each of the four sample areas adverse effects on wildlife will be greatly magnified. In many cases they will impact heavily on local populations. Raptors will be grossly affected, mainly by the mere presence of many more people. Consumptive use of all big game in the four sample areas will be totally changed. Hunters for all species in these areas will find restricted permits, shorter seasons, lower bag limits and success ratios, and greatly increased access problems. Existing fishing conditions in Big Horn County, Montana, and Oliver and Mercer Counties, North Dakota, will be completely changed.

III. IDENTIFICATION OF AREAS WHERE SOUND DECISIONS ARE NOT ASSURED BECAUSE OF A LACK OF INFORMATION

Five areas have been identified:

1. What is the future of the population of pronghorn antelope?

In 1970 an estimated 75 percent of the total world population of pronghorn antelope inhabited Montana, Wyoming, North Dakota, and South Dakota. (Sundstrom, Hepworth, and Diem, 1973) Five percent of the total inhabited Colorado and Utah. (Figure 1.) Extensive coal, oil, gas, uranium, and oil shale development is proposed in these states. The coincidence of the better antelope habitat in Wyoming with that State's rich mineral deposits is cause for concern. This analysis does not indicate serious concern for loss of antelope habitat except in the Extensive Development Forecast, then only in the year 2000. However, simultaneous development of other minerals in the best habitat of this species may jeopardize its ability to maintain large populations beyond the year 2000.

2. What is the future of hunting the population of sage grouse?

The distribution of the sage grouse is similar to the range of the pronghorn antelope. (Figure 2.) In 1972, about 58 percent of all sage grouse harvested by sportsmen were taken in Montana, Wyoming, Colorado, Utah, and the Dakotas. (Pyrah, Watts, Wallestand, and Trueblood, 1973) A large influx of hunters seeking the sage grouse will drastically change hunting conditions for the sage grouse in the NGPRP study area by the year 2000, Extensive Development Forecast. Will the same degradation occur on a large scale throughout sage grouse ranges which now provide over half of the sport harvest?

3. What is the future of the nesting population of golden eagles and the wintering populations of golden and bald eagles in the Western United States?

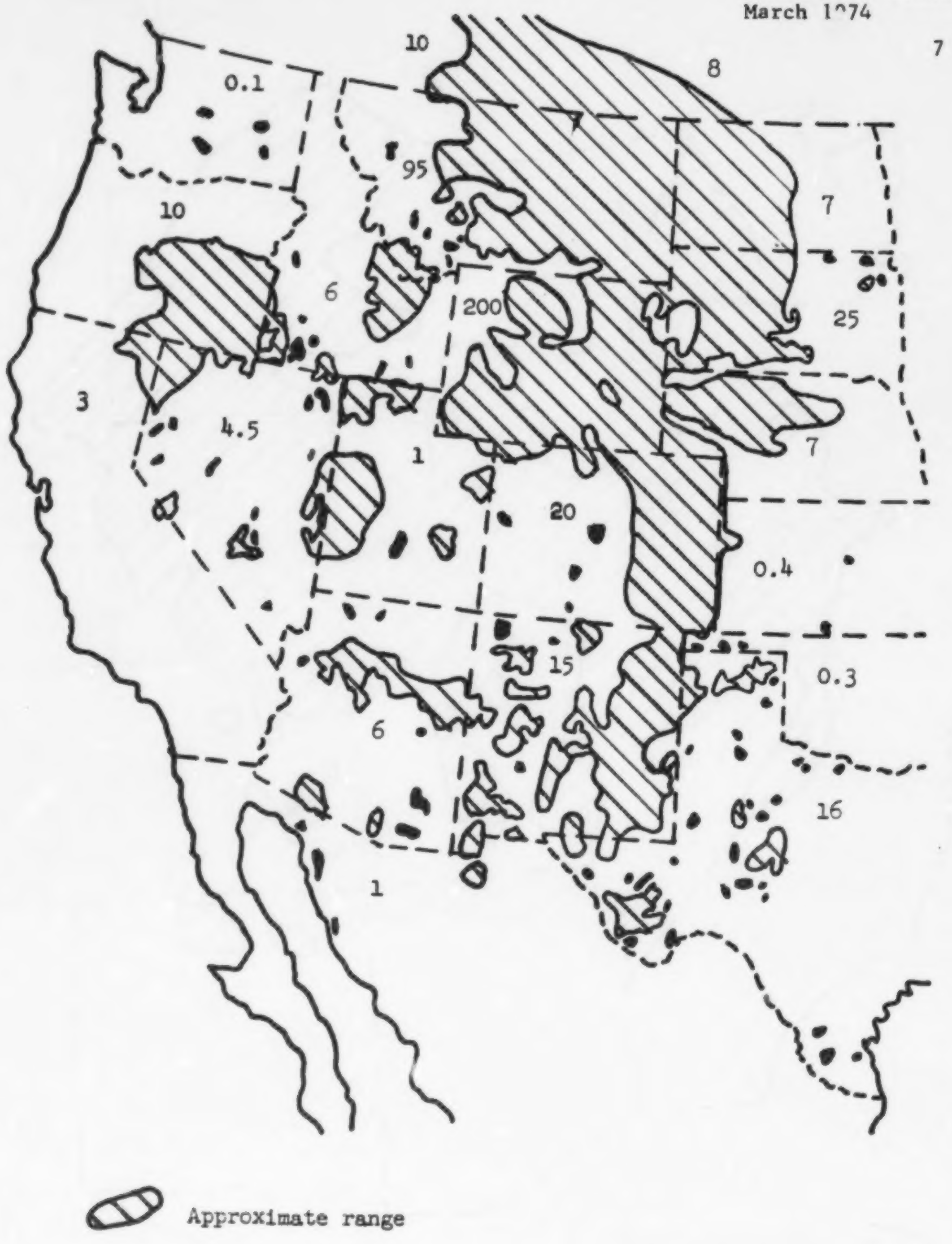
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Figure 1. Range of pronghorn antelope in North America and 1970 estimated numbers, by states and provinces, in thousands. Adapted from Sundstrom, Hepworth, and Diem, 1973.

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March 1974

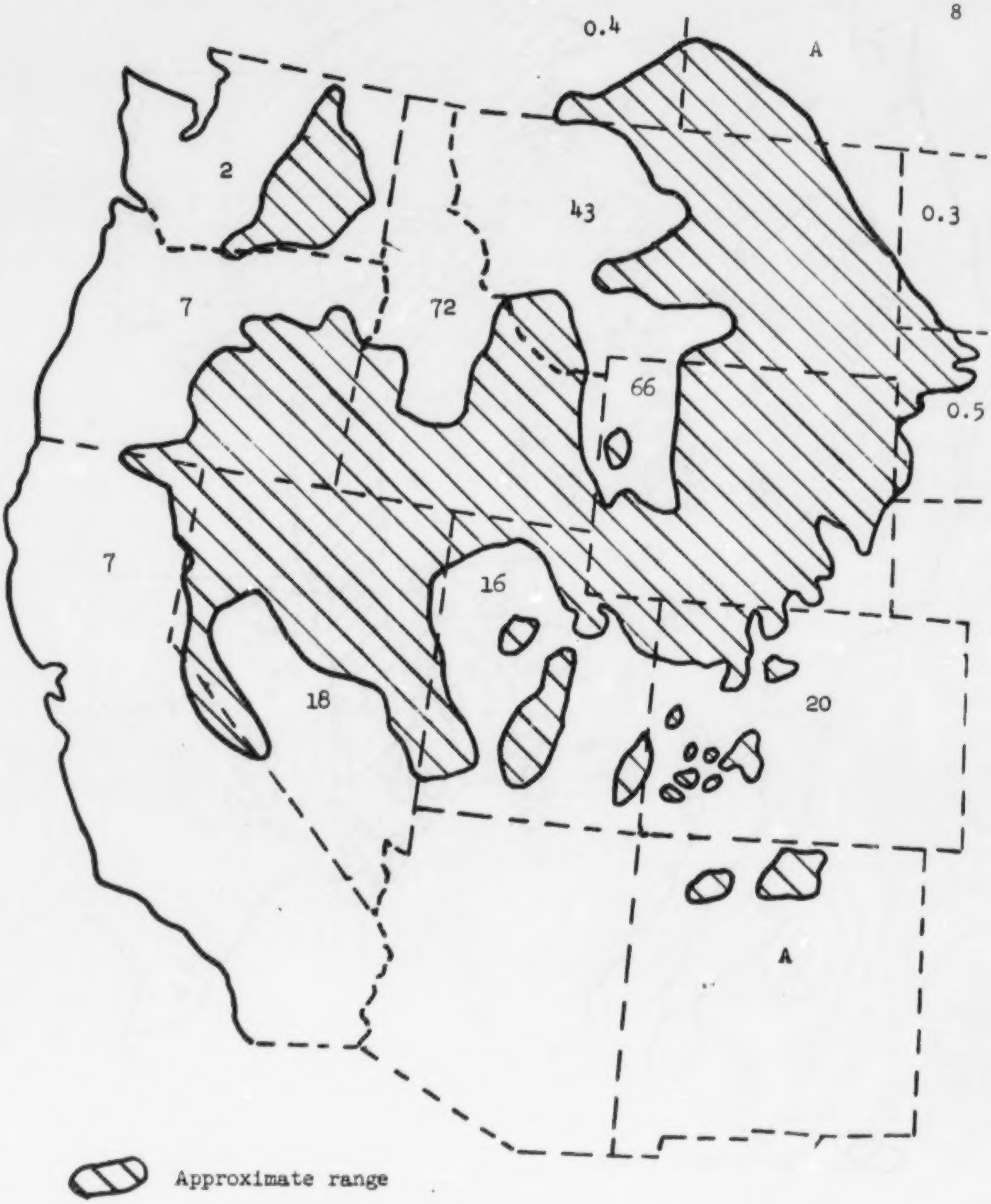
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Figure 2. Range of Sage Grouse in North America and estimated 1972 harvest by States in thousands of birds. Adapted from Proceedings, 8th Western States Sage Grouse Workshop, August 1973, Lewistown, Montana.

The 1972 and 1973 eagle surveys indicated large populations of golden eagles and significant numbers of bald eagles wintering in Montana, Wyoming, and Colorado (Wrakestraw, 1972, and Roop, 1973) A significant number of golden eagles nest in the region. The NGPRP projects large-scale development and major human population increases. What will happen to the region's small mammal populations - crucial to eagle winter survival - and how will more people affect the eagles? How will pollutants from stack emissions affect these predators?

4. What will happen to the water resources of the study area?

The Water Work Group is addressing this crucial issue but within the period of analysis this subgroup has not received sufficient data to permit meaningful analysis of impacts on any aquatic resources including the following: fish, aquatic invertebrates, aquatic vertebrates (amphibians and reptiles), water birds, waterfowl, and furbearing mammals.

5. What effects will stack emissions of power generation and coal gasification plants have on fish and wildlife and their habitat?

This is the most critical unknown facing the Fish and Wildlife Subgroup. Large-scale development projections indicate the probability of environmental degradation on a large scale. No data are available to the subgroup on projected stack emission effects; therefore, this analysis fails to consider what may be the greatest effect of coal development. Consider the following excerpts and paraphrased comments from the draft report, Southwest Energy Study, Appendix H-2, April 1972:

"The principal gaseous air pollutants from the coal-fired power plants include sulfur dioxide and nitrogen oxides. Conversion to the more toxic nitrogen dioxide is also expected to occur." (p. 7)

"Particulate matter containing a variety of trace elements is a potential problem, but no confirmatory data yet exist except for some on mercury." (p. 7)

"Estimated short-term concentrations of sulfur dioxide in excess of 1,000 micrograms per cubic meter are forecast for the vicinities surrounding each of the powerplants for which an atmospheric diffusion model was made. The forecast concentrations for oxides of nitrogen are nearly as high. Because these two gases are synergistic in their toxicity to vegetation, these projected short-term concentrations are enough to pose serious threats to vegetation." (p. 7)

"The plume from a high stack will touch down at greater distances than the plume from a short stack, by the fallout zone will be larger with the higher stack. Thus, high stacks may minimize acute biological effects close to the stack, but they also extend the range over which chronic biological effects may occur." (p. 8)

"Toxicological studies have shown that atmospheric particles may elicit pathological responses in at least two ways. First, the particle may be intrinsically toxic like sulfur trioxide, lead, beryllium, or asbestos. Secondly, inert particulate matter may serve as a carrier of toxic materials such as sulfur dioxide aerosols." (p. 8)

"Laboratory studies have shown four general responses of animals to air pollutants: (1) development of pulmonary edema in some animals; (2) lessened immunochemical response; (3) reduced Vitamin C in blood; and (4) synergism or ther intensification of the toxic effect from combinations of certain pollutants. Thus, it is possible that animals including domestic cattle, swine, horses, and sheep, as well as terrestrial wildlife populations downwind of these powerplants may develop chronic susceptibilities to respiratory diseases as well as other so-called natural diseases." (p. 9)

Inhalation of sulfuric acid mist causes distress or death from laryngeal spasm and deep lung damage in animals. The degree of lung damage is dependent on total dosage rather than on concentration. "This indicates the cumulative effect of sulfur dioxide inhalation may cause loss of wildlife populations over a long period of time, despite the fact that sulfur dioxide concentrations are kept within ambient air quality standards during this same period." (p. 10)

"As mentioned earlier, the chief hazard to terrestrial animals near these powerplants will be the ingestion of vegetation contaminated with fallout from the plume." (p. 11)

"After entering plant leaves through the stomata, acute doses of sulfur dioxide may produce necrosis and/or suppression of plant growth. Therefore, wildlife dependent on vegetation for food is faced with the double threat of a diminished amount of food, as well as the direct ingestion of contaminants." (p. 11)

Plants listed as particularly susceptible to sulfur dioxide and nitrogen dioxide included alfalfa and ponderosa pine. (p. 18)

"Aquatic organisms, as well as man, will concentrate mercury within their bodies when the intake rate exceeds the elimination rate. The result is a buildup with time to the extent that accumulated mercury can become toxic and eventually lethal." (p. 12)

"Obvious candidates (for mercury poisoning) are eagles, peregrine falcons, ospreys, pelicans, mergansers, and minks." (p. 15)

"When sulfur dioxide and nitrogen dioxide are both present as pollutants, as will occur near the coal-fired powerplants, vegetation may be injured at a much lowered concentration because of the synergism of the two gases." (p. 22)

Fluoride emissions pose a possible problem. "It is well known, however, that certain plants accumulate fluorides and are thereby damaged when exposed to extremely low level concentrations of airborne fluorine. Ponderosa pine needles, for example, show necrosis when exposed to less than 1 part per billion of fluorine for one week. Cattle are reportedly prone toward poisoning when they eat vegetation containing 35 ppm fluoride." (p. 28)

If stack emissions are later projected in significant amounts, the following species may be most adversely affected: deer, elk, turkey, all predators (include large and small mammals and all raptorial birds), all game fish, and passerine birds.

In the study area, deer, elk, and turkey depend especially on the ponderosa pine ecotone. This ecotone may be jeopardized by fluoride emissions. Most predators, including mammals and most game fish, would be affected because of the biological concentration of many toxic materials in fatty tissues of animals in a contaminated food chain.

Airborne pollutants may have indirect effects of which weather modification is an important consideration. The relatively unpolluted condition of air in the region is destined for change downwind from coal development operations and installations and from increased residential and industrial development. The potential impact on local weather is unknown. However, a small alteration in annual precipitation in this semi-arid region could have significant, long-term effects on fish, wildlife, and their habitat.

Coal sizing and ash handling may contribute to local and regional air pollution and have deleterious effects on habitat, fish, and wildlife.

IV. IMPACTS OF DEVELOPMENT ON FISH AND WILDLIFE

Besides the direct loss of habitat from mine, powerplant, and gasification plant construction and operation, related developments may have equally severe impacts on fish and wildlife. This analysis considers only direct loss of habitat attributable to projected water developments provided by the Water Resources Work Group. Impacts which have not been quantified are discussed in general below.

Water development

Five-hundred and forty miles of aqueducts and spur lines and 4,000 acres of land for one reservoir are projected for the extensive development forecast. A 200-foot right-of-way will be reclaimed to natural conditions within twenty-five years. Permanent maintenance roads having a 30-foot width will require 1,964 acres of land.

Primary impacts will be from disruption of 13,100 acres of land and ground cover during aqueduct construction, loss of 1,964 acres of land to permanent maintenance roads, esthetic losses as may be associated with permanent facilities and inundation of 4,000 acres of bottomlands for Pumpkin Reservoir.

The 13,100-acre loss of vegetation will persist for an estimated five years, after which some vegetative cover will be restored. However, for this analysis, the subgroup assumed a minimum of 25 years for restoration to natural vegetation composition and quality. (See explanation of Basic Assumptions of Analysis in Section VIII, Procedures.)

The methods of water storage and diversion, alteration of stream flows and transbasin diversion have tremendous impacts on fish and wildlife resources. The amount of water in a stream channel determines, in part, the carrying capacity of that water body to support aquatic invertebrates, fish, and such other aquatic vertebrates as amphibians, reptiles, water birds, and furbearing mammals. Seasonal variations in flows affect spawning, nursing, feed, and migration and partially determine what species are present. Water flow and temperature during winter determines whether the stream will remain ice free and thus able to provide a resting area for wintering waterfowl. The amount of shallows a stream channel provides at a given flow determines the feeding area available to shorebirds which feed on aquatic invertebrates. Flows influence streamside vegetation patterns and amounts. Beaver, muskrat, and some big-game mammals depend on aquatic or riparian vegetation.

Even slight water manipulation may have far reaching implications for wildlife. For instance, birds and mammals dependent on water at a spring or seep may be seriously affected if groundwater patterns were disrupted, for example--stopping the flow of a spring, or if a spring were developed and water piped downhill for livestock, domestic, or industrial use.

In addition to amount and availability of water, quality determines species diversity. Process water from gasification plants may carry a variety of pollutants: phenols and cresols, light aromatics, some soils and tars, ammonia, sulfur compounds, traces of hydrogen cyanide, coal char, and ash. Gasifier ash may have the potential for the leaching of salts. If ash disposal is by burial, contamination of groundwater or surface water run-off may be hazardous for fish, wildlife, and vegetation.

Transmission lines

Wildlife mortality from electrocution and in-flight wire strikes are quite common, particularly in localities where transmission lines cross normal paths of movement either for local feeding activity or during seasonal migrations. Birds that migrate in large flocks have the greatest susceptibility to line strikes and raptors are common victims of electrocution. The large steel towers used for high voltage transmission are believed to cause little if any raptor mortality by electrocution.

The construction of transmission lines disrupts ground cover within the line corridor. In forested areas, trees are removed with accompanying land surface disturbance. In grassland areas, land surface is less disturbed but vehicular traffic and construction activity does adversely affect vegetal cover. On slopes, erosion can be a temporary problem causing sedimentation of streams until revegetation is accomplished. Maintenance roads may be a continuing influence in the corridor particularly if herbicides or sterilants are used to control vegetation.

Natural beauty of an area can be adversely affected by transmission lines and towers. The impact of these effects can be reduced by proper corridor selection and proper construction, cleanup, restoration, and maintenance practices.

Electrical effects of transmission lines include the corona effect; electromagnetic induction; and electrostatic induction effect. (Westinghouse, 1973) Impacts of electrical effects on wildlife resources are largely unknown.

Under the extensive development forecast, 1,411 miles of line will be constructed and 82.2 square miles of right-of-way will be used. Because of the characteristics of the facilities, local impacts may be minimal; but regionally, the effects on raptors and migratory birds may be moderately damaging.

Highways

Road construction occupies land area and habitat. Natural vegetation is usually destroyed and soil erosion may commonly occur, at least, for a short period of time and longer when ground cover is not restored. Where roads follow stream or river bottomlands usually the better wildlife habitat is fragmented or destroyed.

Stream water pollution is a common problem. In some localities, the completed road and commonly associated fencing will be an impediment to movement of some big-game animals. Direct mortality (road kill) to all indigneous wildlife species will be a common and regular occurrence. The added mortality will reduce recreational use of all species affected.

Emissions from vehicles will be added to the roadside ecosystem. Road maintenance requiring herbicide application also adds to the alterations in the adjacent environment.

New roads increase accessibility to fish and wildlife resources. This, in turn, adds to the legal and illegal consumptive use of local species. Non-consumptive use such as animal watching and photography will be increased.

Roads in scenic areas can destroy esthetic values. Route selection, shaping of grades, cleanup of construction disturbances, and restoration of ground cover can minimize adverse impacts. A multitude of interlacing poorly constructed and planned roads can cause havoc to an area. Such development may occur in the vicinity of mine-mouth operations with a power or gas production plant.

Three-hundred and twenty miles of new road and 12,455 acres of right-of-way are projected under the extensive development forecasts. With proper planning and safeguards, the overall environmental impact could be minimized.

Railroads

One thousand and eleven miles of additional railroad track are projected under the extensive development forecast. Six thousand and twenty-nine acres of permanent right-of-way and an additional 19,724 acres of temporary right-of-way are needed for construction.

The construction period will cause long-term loss of native habitat on 25,763 acres of land. Maintenance of the permanent right-of-way 6,029 acres will probably cause permanent loss of numerous native plants. However, the right-of-way area not used by trackage will create some beneficial diversity where adjoining habitat presently is characterized by a vegetational monoculture. Soil erosion may be a serious pollution problem where construction occurs near flowing streams.

Other adverse impacts include direct wildlife mortality by collision with trains, contamination from train and right-of-way maintenance, fires started by trains, attendant fencing and reduced mobility of big game, esthetic degradation, and increased public accessibility.

Urban development

The influx of people for the construction and operational phases of the coal development program will have significant impacts on fish and wildlife. The construction force will be temporary and most living facilities provided for them will be temporary. Plant operations will bring in permanent personnel and require permanent living facilities and land.

Impacts from the construction force will be temporary in a given locality. Their imprints, however, may be deep. General areas of adverse influence on fish and wildlife are: esthetics, sanitation-water problems, fish and game demand (legal and illegal), temporary scattered housing and related effects on habitat. Construction areas in the West have often carried some of these "temporary construction scars" for 10 to 15 years or longer following project completion.

Permanent operating personnel will create impacts similar to construction forces, but for a longer period. New towns may cause direct or indirect loss of fish and wildlife habitat from siting. The influence on demand and behavior will extend beyond the siting area for most fish and wildlife. Community impact on a pristine area may extend possibly 50 miles or more.

Noise

Noise levels near any of the coal related activities will rise sharply over natural conditions. Noise transmission will extend beyond the acreage of habitat affected by construction and operations. Excessive noise has been related to physiologic stress and interference with breeding behavior of mammals. How wildlife populations in developed areas will be affected by noise is conjectural.

Fish and game department revenue structures

The western states and Montana and Wyoming in particular provide well known hunting and fishing opportunities for the non-resident sportsman. The fish and game departments of these states derive a significant portion of their operating revenues from non-resident hunting and fishing license fees as shown in Table 2. below.

Table 2.--Non-resident contribution to fish and game department revenues in Montana and Wyoming 1/

	Montana 1970	Wyoming 1970
Hunting and fishing fees paid by non-residents	$2,422,933	$4,253,278
Total department revenue from all sources	$5,731,931	$6,233,011
Percent non-resident fees are of total revenue	42	68
Big game license fees paid by non-residents	$1,961,445	$3,509,120
Percent non-resident big-game fees are of total revenue	34	56

1/ Marker, 1974, and Montana Department of Fish and Game, 1972.

Currently, non-residents pay five to ten times as much as residents for licenses and permits to hunt big-game animals. In both Montana and Wyoming large numbers of non-residents hunt elk, deer, and antelope. Moose, bear, bighorn sheep, and mountain goats are hunted by a prescribed number of non-residents. As the number of resident hunters increase, they will likely demand a reduction in non-resident hunting permits. License fee revenues would then decline substantially with even moderate decreases in non-resident license sales. Funding of state fish and game departments from general state revenues is considered unlikely and more people pressure and habitat losses will require even more intensive game management. Residents will likely have to pay more for their hunting privileges.

V. REGIONAL IMPACTS ON FISH AND WILDLIFE RESOURCES

A. Base forecast

In the Base Forecast, by 1980 more than 6,000 acres of land will be occupied or physically disturbed by coal development in the NGPRP study area. The human population will increase by about 4 percent over that of 1970. Except for some species which are threatened or endangered and for some local wildlife populations, effects on fish and wildlife habitat in the region will be minor. Species in the region which are threatened with extinction include the black-footed ferret and the American peregrine falcon. The whooping crane is a spring and fall migrant through the region. Species threatened with extinction, but about whose populations little is known, are called status-undetermined species. In this analysis they are occasionally collectively referred to also as "endangered species". (Refer to the Regional Profile of Fish and Wildlife resources for a listing of status-undetermined species resident in the area.)

Populations of the American peregrine falcon have declined drastically in the last 30 years, and is attributed to the accumulation of chlorinated pesticides obtained from the birds' prey. However, habitat destruction, nest molestation, and capture of young and adults for falconry have been cited as factors in the decline (BSFW, 1973). Most peregrine falcons in the region are spring and fall migrants: however, in 1969-70, one known aerie with adults present was recorded each in Montana and Wyoming. Despite warnings by concerned individuals, people continue to use chlorinated pesticides and knowingly or unwittingly molest bird nests. Any human population increase in the region will probably seriously affect this species.

Hunting for elk in the study area and for elk, moose, bighorn sheep, and mountain goat in Montana and Wyoming west of the study area will change even by 1980. Of the 21,000 new residents expected in the area, about 2,000 will hunt these species. They will compete with present residents and with the thousands of non-residents willing to pay higher license fees and guide fees. In Montana and Wyoming most elk hunting districts are not now restricted to a harvest quota, and antlerless seasons are common. By 1980, more districts will likely have antlerless elk hunting by permit only. In Montana two sheep hunting districts do not restrict the number of hunters. It is doubtful that unlimited hunting will persist until 1980. All other moose, bighorn sheep, and mountain goat hunting in Montana and Wyoming is by special permit only. By 1980, North Dakota will probably have limited bighorn sheep hunting annually and South Dakota now has an open limited permit mountain goat season. Currently competition for all these permits is intense--in Montana in 1972 there were 24,753 applications for 673 moose permits, 6,152 applications for 72 sheep licenses, and 7,855 applications for 665 goat licenses (Montana Outdoors, September-October, 1972). By 1980, even more hunters will vie for the limited permits.

The ring-necked pheasant is a colorful exotic game bird known all over the country for providing outstanding upland game hunting in the Dakotas. It is also eagerly sought in Montana and Wyoming. Changing agricultural practices have drastically reduced pheasant populations in the region in the last 5 to 7 years, but hunting pressure is still tremendous. Hunters new to the region will attempt to pursue the pheasant and will likely compete with current residents for that privilege, often by leasing exclusive hunting rights. By 1980, pheasant hunting may begin to be a sport of the fortunate, at least near population centers.

Another large game bird which will receive disproportionate hunting pressure from new residents is the sage grouse. Next to the turkey this is the largest upland game bird in North America. Where it abounds it is far easier to harvest a sage grouse than a wild turkey. Much of the better sage grouse habitat is on public lands. Presently, in Montana and Wyoming, most sage grouse populations are underharvested and could support significantly more pressure. By 1980, this increased harvest potential may be realized from pressure of new hunters.

In the Base Forecast, by 1985 17,000 acres will be lost to development and the population will increase by 30,000, or 6 percent over 1970 levels. The increased population may cause an additional decrease in the habitat of the peregrine falcon, since the spring and fall migration habitat of this bird encompasses most of the northern prairie, and more people will occupy that habitat. There will be slight but important decreases in ring-necked pheasant and wild turkey habitat. In the Dakotas the pheasant is widely distributed and much of those states is pheasant habitat. However, the best habitat is the irrigated bottomlands. Although the turkey is widely distributed, particularly so in the center of the study area, it is restricted to small areas of suitable habitat. Pheasant habitat in Montana and Wyoming is also restricted generally to such locales as river bottomlands.

Hunting pressure for elk will increase both in the study area and to the west. Applications for moose, bighorn sheep, and mountain goat hunting permits will increase slightly. Hunting pressure on sage grouse and on ring-necked pheasant in the western part of the study area will increase so that the average hunter's success will noticeably decrease.

By the year 2000 development will have occupied more than 50,000 acres and 65,000 more people will reside in the area than did in 1970. It is probable that the peregrine falcon will no longer nest in Montana or Wyoming by that time, and spring and fall migrants, will be reduced to a very rare visitor. The black-footed ferret, an endangered species, inhabits much of South Dakota in the study area and has been verified in North Dakota and Wyoming in recent years. It is suspected to be present in Montana but no verified sightings have been made since the 1950's. The ferret inhabits prairie dog towns where his main prey species, the black-tailed prairie dog resides. They have and continue to provide sport varmint hunting. As long as small mammal population suppression through use of poisons is restricted, it is probable that varmint hunting will be condoned, and on ranges where livestock are present, encouraged. Consequently, increased human populations will adversely affect prairie dogs, the prey, and hence black-footed ferrets, the predator.

The western burrowing owl is a status-undetermined species also dependent on the black-tailed prairie dog. The burrowing owl frequents abandoned prairie dog burrows. Significant decreases in the number of prairie dog towns would adversely affect the western burrowing owl.

Inexplicably, some people shoot hawks. The ferruginous hawk, prairie pigeon hawk, and prairie falcon are status-undetermined species resident in the study area. The projected human population increases for the year 2000 causes serious concern for these birds of prey.

Losses of game animal habitat will affect the wild turkey the most but sage grouse and ring-necked pheasants will lose significant habitat areas. Although only 5,900 acres of turkey habitat will be destroyed, the losses will occur in some of the better habitat areas. The sage grouse has experienced significant habitat losses recently because of largescale sagebrush eradication programs. Under this forecast an additional 24,000 acres of good and medium quality habitat will be lost. In view of trends, this is significant. In the region, better sagebrush habitat exists north and southwest of most development.

Also in view of present trends, the loss of an additional 5,800 acres of good and medium quality ring-necked pheasant habitat assumes significance, particularly to the west of the Dakotas.

Regionally, most hunting will be moderately changed by the year 2000. There will be an estimated 13,000 more deer hunters, 3,300 more antelope hunters, and 7,600 more hunters seeking other big-game species. If availability of non-resident hunting permits indicates a harvestable surplus of big-game animals in excess of resident needs, (at least for deer and antelope this hypothesis appears valid for Montana and Wyoming) then the number of non-resident permits available in 1970 would easily satisfy harvest demands of new residents, Table 3. However, as stated earlier, any significant reordering of the resident : non-resident license ratio in Montana or Wyoming would adversely affect either state's fish and game department revenue structure. There will probably be some reduction in number of non-resident hunting permits, but resident hunting opportunities by the year 2000 will be more limited than now. Seasons will probably be shortened. It is doubtful the two-deer bag limit for both residents and non-residents in Montana would last much beyond 1985.

Table 3.--Number of non-resident big-game license holders[1] in Montana and non-resident big-game hunters in Wyoming in 1970.

	Montana[2]	Wyoming[3]
Deer	10,329	80,019
Antelope	4,665	15,471
Elk	9,501[4]	5,240
Bighorn sheep	172	102[5]
Mountain goat	247	1
Moose	32	319[5]

1/ In Wyoming 2 percent of non-resident deer license holders and 4 percent of non-resident elk license holders did not hunt. This same ratio may apply to Montana license holders.

2/ Data from Montana Department of Fish and Game, 1972.

3/ Data from Wyoming Game and Fish Department, 1971.

4/ Holders of Montana non-resident big-game licenses are also entitled to take 2 deer and must purchase this license before hunting moose, sheep, goats, or grizzly.

5/ Number of permits issued rather than number of hunters.

In both North Dakota and South Dakota non-residents are allowed to hunt big game; however, the percentage of non-resident hunters is very low. Increases in number of resident hunters in those states will result in decreasing opportunity to hunt deer and antelope.

Because of their uniqueness increased hunting pressure on sage grouse will lead to a deterioration in hunting quality - seasons will be shorter and bag limits will be reduced. Pheasant hunting will be similarly affected. Other upland game species will support all the additional hunting pressure in this forecast. Access to private land will be more difficult; on the other hand, development of new roads on public land will increase access to public lands. The net effect will remain negative.

Locally, popular fishing sites will become overcrowded, but regionally fishing demand will not exceed the supply.

B. Most probable forecast

By 1980, the Most Probable Forecast development will have covered or disturbed 6,500 acres. The population of the area will increase by 25,000 over that of 1970. This represents little change from Base Forecast projections for the same year. In summary, throughout the region, habitat for the American peregrine falcon will deteriorate mainly as a result of continued use of chlorinated pesticides by people. Other raptors will be lost from roadside shooting, collision with vehicles, electrocution from small trasmission lines, poisons directed at the raptors and at other predators and even their prey species, concentration of toxic materials through the food chain, and by steel traps intended for furbearing mammals.

Prices of many furs skyrocketed at the spring 1973 fur auctions. There has been a tremendous increase in trapping pressure in the 1973-74 trapping season over previous seasons. Raptor mortality from trapping is estimated to have increased accordingly. If new residents increase the trapping pressure trends, raptors, including wintering bald and golden eagles, will be greatly affected.

Regionally, little besides raptor habitat will be significantly affected. Deer hunting in North Dakota will have noticeably changed - mainly by increased access difficulty and decreased permit opportunity - but elsewhere neither deer nor antelope hunting will be noticeably changed. Hunting for other big game will have changed slightly in that elk hunting conditions will be more restricted and opportunities to hunt other species will be reduced. Of upland game hunting only sage grouse and ring-necked pheasant hunting will be regionally affected - by a few less birds, shorter seasons, and for pheasants, more restricted access to hunting areas.

Regionally, fishing opportunity and quality will be little affected. Locally, however, trout fisheries and certain reservoir fisheries will begin to receive excessive pressure.

By 1985 more than 26,000 acres of land will have been disturbed, destroyed, or occupied. The area's population will increase by 65,000--a 13 percent increase over 1970. The population increase is comparable to the Base Forecast in the year 2000, but the land disturbance related to coal development is only half that projected for the year 2000, Base Forecast. We believe human population increases will have greater impacts on fish and wildlife than will land disturbance attributable directly to coal development. For this year, then, we project approximately the same impacts on fish and wildlife resources as projected for the Base Forecast, year 2000. One mitigating factor is that the impacts would have 15 fewer years to be realized; for some species and hunting situations, such as sage grouse hunting, that may be significant.

By the year 2000, Most Probable Forecast, the area's human population will have swelled by 32 percent or 164,000 more people than in 1970. More than 95,000 acres will be sacrificed to coal development. Adverse impacts on wildlife resources and on hunting will be significant.

Because of the magnitude of change, we project the extirpation of the peregrine falcon in the study area, both as a summer nester and as a spring and fall migrant. We also project significant reductions in population levels of all raptors.

By year 2000, enough better habitat of white-tailed and mule deer, sage grouse, ring-necked pheasant, and wild turkey will have been destroyed to cause serious concern among game managers and to be readily noticed by the outdoor public. Hunting for all big-game species and some upland game (sage and sharp-tailed grouse, pheasant, turkey) will be seriously downgraded. There will be 27,700 more deer hunters, 5,800 more antelope hunters, and 12,715 new hunters of other big-game species residing in the area. Sage grouse, sharp-tailed grouse, and pheasant hunters will increase by 11,309, 11,843, and 16,179, respectively. And because of habitat losses, there will also be fewer game animals. Although the increase in turkey hunters is only projected to be 312, the regional increase will be enough to change turkey hunting in Montana. Currently, in Montana turkey areas there is unlimited hunting restricted only by season length and bag limits. In the other states turkey hunting is by special permit only. Spring gobbler hunting in Montana may be limited by special permit only by about 1985. By the year 2000, all turkey hunting in the region will probably be by special permit only.

Significant increases in numbers of hunters and slight decreases in harvestable surplus of game animals because of habitat losses will result in greater hunting restrictions. Seasons will be shorter, bag limits will be reduced (in Montana the two-deer limit will likely be reduced to one deer), hunting opportunity for some species will decrease (grizzly hunting in Montana and mountain lion hunting in Montana and Wyoming; moose, goat, and sheep hunting in both states; and deer and antelope hunting in the Dakotas will all be by permit only and an individual's chance for drawing a permit will be greatly reduced from present levels) and access, in most cases, will be more restricted. Each of these factors, except for use of specially drawn permits, will greatly suppress current hunter success ratios. The entire region has traditionally enjoyed phenomenally high big-game hunting success ratios, Table 4.

Table 4.--Big-game success ratios in Montana and Wyoming in 1970[1]

	Montana	Wyoming
	Percent	
Deer	80	75
Antelope	76	93
Elk	18	43
Bighorn sheep	15[2]	34
Mountain goat	44	75
Moose	86	93

[1] From Montana Department of Fish and Game, 1972 and Wyoming Game and Fish Department, 1971.

[2] This figure significantly depressed by including 447 hunters who harvested only 31 rams in unlimited areas.

Significant decreases in success ratios for deer, elk, and antelope will adversely affect the non-resident guiding and outfitting industry. Non-residents traveling long distances would rather drive a little farther to areas where chances for harvesting game were better.

C. Extensive development forecast

In the Extensive Development Forecast, by the year 1980, almost 19,000 acres of wildlife habitat will be destroyed by coal development. The population of the region will increase by 69,000 people - a 14 percent increase over 1970. Habitat losses are roughly comparable to 1985 losses under the two other forecasts. Population increases are comparable to the year 2000 in the Base Forecast and the year 1985 in the Most Probable Forecast. Since 1980 is only six years hence, it is improbable that impacts on fish and wildlife would be realized to the same magnitude in that short time than they would in 26 years under the Base Forecast. Rather, regional impacts in 1980 under the

Extensive Development Forecast should be roughly comparable to impacts in 1985 under the Most Probable Forecast--with one exception. Under Extensive Development projections, more development occurs in better turkey habitat, so turkeys will be seriously affected as early as 1980 in this forecast.

The 1985 Extensive Development impacts on wildlife resources and fishing are comparable to impacts occurring by the year 2000, in the Most Probable Forecast, discussed above.

By the year 2000 in the Extensive Development Forecast the area's population will increase by 416,584 or 82 percent. Coal development will have destroyed almost 300,000 acres of wildlife habitat. We project the following impacts on wildlife resources and hunting and consider them a disastrous change from present conditions:

1. 277,000 acres of good and medium quality deer habitat will be lost - yet almost 69,000 more deer hunters will compete with the current number of hunters for less deer.

2. Hunting for elk in Montana and Wyoming will be vastly changed. There will be over 29,000 more resident elk hunters in those states. Hunting opportunity for both resident and non-resident hunters will decrease significantly and the hunter success ratio will decrease noticeably in Montana and alarmingly in Wyoming.

3. Sage grouse hunting has had a long-term trend in the region toward longer seasons and more liberal conditions. This trend will be abruptly reversed and by the year 2000 sage grouse hunting will be far more restricted.

4. Over 83,000 acres of turkey habitat will be destroyed. This destruction will occur in five of the ten largest areas of high quality turkey habitat in the study area. Turkey populations will be much reduced; however, a harvestable surplus will be available annually and turkey hunting will continue, although under far more restricted circumstances than at present.

5. Raptors will loose 295,000 acres of hunting grounds and will be subject to intentional or unintentional persecution by 400,000 more people. Impacts on resident raptors will be significant; impacts on wintering raptors is speculative.

6. Local populations of passerine birds will be eliminated. Effects on many species will be long term because it is unrealistic to project restoration of distrubed lands to natural levels of plant variety within a short time frame. Currently, the relationships of the hundreds of passerine species to the several ecosystems of the area is little understood by game biologists and land managers. Twenty-five years ago the roles of minute organisms in coastal estuaries and freshwater swamps were understood by few. Today, almost too late, people are beginning to appreciate the importance of the estuaries and swamps as nurseries, reservoirs, and even kidneys to river systems. Probably the small birds and mammals serve a far greater role in the prairie ecosystems than is widely appreciated.

7. Local populations of some endangered or threatened species will likely be extirpated. Any loss of individuals of these species would be disastrous. Candidates for losses include: American peregrine falcon, black-footed ferret, prairie falcon, prairie pigeon hawk, western burrowing owl, mountain plover, northern long-billed curlew, and ferruginous hawk.

Many species will be affected enough to cause serious concern; however, impacts to regional populations will not be disastrous. Over 200,000 acres of good and medium quality antelope habitat will be destroyed, but most coal development does not occur on hundreds of thousands of prime antelope habitat. Elk habitat in the Laramie Range, Bull Mountains, and Black Hills will be affected by projected powerlines and roads. Bighorn sheep habitat in the Laramie Range and along the breaks of the Little Missouri

River will be damaged by transmission lines. Because the study area provides little habitat to these species, any impact is significant; yet, these intrusions will not be disastrous to regional populations.

If competition for water reaches such a point that even a few small reservoirs are constructed in high mountain meadows on national forest lands of the Big Horn Mountains, the small moose population (approximately 100 individuals) may be reduced below a maintenance threshold and extirpated. Extirpation of a species from an entire mountain range would be disastrous. Other than the turkey, only enough habitat of the ring-necked pheasant will be destroyed (122,000 acres) to cause serious concern. Habitat of other upland species will be affected, but development does not coincide with much of the best habitat of other upland species in the region.

There is a potential for substantial regional impacts on waterfowl through river manipulation and other water developments; however, data on this issue are insufficient to permit projecting impacts. Where industrial discharges would keep waters ice free through the winter, wintering waterfowl populations would increase, and waterfowl hunting would be beneficially affected. On the other hand, large concentrations of waterfowl on small areas greatly increases the chances for epizootic diseases to cause large losses.

Local impacts from increased numbers of fishermen will be tremendous but the regional supply of fishing opportunity will still exceed the demands in the year 2000.

VI. IMPACTS ON FISH AND WILDLIFE RESOURCES IN THE FOUR SAMPLE AREAS

A. Campbell County, Wyoming

1. Base forecast

In the Base Forecast, by 1980 in Campbell County only 1,000 acres will be disturbed or destroyed by coal development, but the population will have increased 35 percent since 1970. Most impacts on wildlife resources will result from the increased human population. Few game species will be significantly adversely affected. A projected 35 percent increase in deer and antelope hunters will cause a noticeable change in big-game hunting conditions in the County, but good, nearby deer areas out of the County could easily absorb increased resident hunter pressure. Small game hunting will be little affected. There are few good fishing areas in Campbell County. Most fishing by County residents occurs at Lake DeSmet and in the trout streams of the Big Horn Mountains to the west or at Keyhole Reservoir to the east. County residents will find these areas crowded by 1980.

By 1985, the population will have increased by 5,000 people for a 39 percent increase over 1970 levels. Coal development will have occupied or disturbed 3,000 acres. Most hunting situations will be little changed from 1980 levels except that as a result of five more years of more hunters, access to private lands will be reduced and more landowners will charge trespass fees. These fees will also apply to small game hunters instead of only deer and antelope hunters. Comparatively little waterfowl hunting occurs in the County and the expected addition of 400 more resident waterfowl hunters will crowd existing river and pond hunting areas in and near the County.

By the year 2000, the population will increase by 8,000--63 percent over 1970 levels. Coal development will claim 9,000 acres. Impacts on the black-footed ferret, could be disastrous. Confirmed ferret observations have been made recently in Crook and Weston Counties, adjacent to and east of Campbell County. Some threatened raptors will be seriously affected by man-caused mortality, primarily through collision with automobiles and by shooting. Status-undetermined raptors inhabiting Campbell County include the prairie falcon, ferruginous hawk, prairie pigeon hawk, and western burrowing owl

Loss of 9,000 acres of good and medium quality deer and antelope habitat in the County is cause for serious concern. An additional 1,600 deer hunters and 569 antelope hunters will reside in the County. If they all choose to hunt in their county of residence, hunting would deteriorate severely. Many deer hunters are expected to hunt to the southwest and in the Black Hills to the east. All antelope hunting is by permit only and many Campbell County antelope hunters will be regulated by the permit system to other antelope hunting areas in the State. A projected increase of 700 pheasant hunters residing in the County will seriously increase competition for access to the little pheasant habitat in the County - most will hunt to the west in Sheridan County.

2. Most probable forecast

By 1980, 1,200 acres will be lost to coal development - comparable to Base Forecast levels of the same year. However, the human population will increase 64 percent over 1970 levels. These population increases will seriously affect all raptors and would be disastrous to ferrets if they are present in the County. Ring-necked pheasants will receive heavy hunting pressure but most pheasant hunters will travel out of the County. The same applies to deer and antelope hunters.

By 1985, habitat on 5,000 acres will be occupied or destroyed. The County's population will increase by 115 percent over 1970 levels. Deer hunters will increase by 2,900, antelope and sage grouse hunters by 1,045 each, and waterfowl hunters by 1,200. Except for antelope hunters dispersed by permits; hunters for these species will find nearby areas overcrowded, access greatly decreased, and the quality of hunting much deteriorated. There will be 2,000 more elk hunters residing in the County. Elk hunting areas are widely distributed around the State and concentrated in the western half. However, the Big Horn Mountains are nearby and support a good elk population. In 1969, there were 5,400 resident and non-resident elk hunters on the eastern slopes of the Big Horn Mountains. An increase of even 1,000 hunters would significantly change existing conditions.

County residents will find fishing at Keyhole Reservoir and Lake DeSmet overcrowded. Trout fishing in the Big Horn Mountains and on Sand Creek in Crook County will be much overcrowded and regulations far more restrictive.

Sage grouse numbers will remain nearly the same in the County, but hunting for this bird will be under more restrictive regulations. Except for pheasants, hunting for other upland species will be little affected. Finding an area to hunt by oneself will be more difficult. Good waterfowl hunting areas will be overcrowded. Hunter success will decrease significantly because of spooked birds.

3. Extensive development forecast

By 1980, the County population will double the 1970 level. Coal development will consume only 1,200 acres by then. Impacts attributable to the doubled population will far exceed impacts caused by loss of 1,200 acres. Only raptor habitat will be significantly affected by 1980. Loss of acreage is not significant to the raptors but the presence of more people is. Mortality from shooting, trapping, and vehicle collision will increase. Of the raptors common in Campbell County, the prairie falcon, ferruginous hawk, prairie pigeon hawk, and western burrowing owl are considered status-undetermined species whose population status is unknown.

Hunting for deer, sage grouse, ring-necked pheasant, and waterfowl in the County will be vastly changed by 1980 because of so many more resident hunters afield. Access to private lands will be more restricted, more landowners will charge trespass fees, and popular areas of public lands, of which there are relatively few in the County, will be crowded. Popular fishing spots used by County residents will be crowded.

By 1985, the County's population will be more than three times the 1970 population. Coal development will have disturbed almost 10,000 acres. Effects on any species whose population is already jeopardized will be disastrous. Both the American peregrine falcon and the black-footed ferret, endangered species, are known to inhabit this general area but we could not confirm their presence in the County.

Raptors will be adversely affected by more people. Some 9,400 acres of the best antelope habitat in the County will be destroyed. This will cause serious concern.

Quality of hunting for deer, antelope, sage grouse, ring-necked pheasant, and waterfowl will seriously deteriorate because of large increases in number of resident hunters, slight decreases in numbers of game animals, and less available private lands to hunting. With an estimated 10,700 more fishermen residing in the County, nearby fishing areas will all be seriously overcrowded.

By the year 2000, coal development will have destroyed over 50,000 acres of wildlife habitat. The County's population will probably increase by a phenomenal 489 percent over 1970 levels. Impacts on all raptors will be disastrous. In losses of habitat alone, enough land to support 9 wintering golden or bald eagles will be destroyed. Wintering eagles are entirely dependent on small mammal populations to survive the winter. The human population increase will cause hawk and eagle mortality to skyrocket.

Coal development will destroy 39,720 acres of good and medium quality deer habitat. This is small in relation to the County's total habitat but most of the development that occurs north of Gillette will be in the County's best deer habitat.

Forty-seven thousand and four hundred acres of antelope habitat will be destroyed. Again, this is small in relation to the County's total antelope habitat. However, the projected railroad from Gillette, south to Douglas will bisect a key antelope winter concentration area. A projected transmission line will also bisect the concentration area. Any loss of key habitat is considered serious.

The railroad track addition projected from near Sheridan, Wyoming, to Gillette will destroy approximately 40 acres of elk habitat used by the Fortification elk herd. While this is small, it represents what is probably the beginning of intrusion into a small protected area.

Even with this development forecast, no significant upland game habitat will be lost in the County. Sage grouse habitat will not be significantly lost in the County until the year 2000, then only 4,700 acres. Some sharp-tailed grouse habitat will be lost but the County is on the periphery of their range. Almost all of Campbell County is considered Hungarian partridge habitat but of low quality. Some partridge populations will be lost. There is very little ring-necked pheasant habitat in Campbell County and it is considered generally of low quality. A small amount of pheasant habitat will be destroyed by the year 2000. Little turkey habitat is in the County and the loss of 676 acres projected, while small, is significant to the County's total.

Although most game habitat losses in the County will not be excessive, the tremendous population increase will be a severe impact to hunting conditions for some species. Deer and sage grouse hunting will be most adversely affected. Antelope, waterfowl, and pheasant hunting will be seriously affected. Many County residents will have to travel out of the County to satisfy their hunting and fishing desires.

Elk hunting and trout fishing in the Big Horn Mountains; deer hunting in the Black Hills; antelope, sage grouse, and chukar hunting all over the State will be adversely affected by pressure from Campbell County residents. Non-resident hunting opportunities in eastern Wyoming will decrease significantly.

B. Big Horn County, Montana

1. Base forecast

In the Base Forecast in Big Horn County by 1980, the population will increase four percent over that of 1970, and coal development will have covered 626 acres. Impacts on fish and wildlife resources will be minor.

By 1985, more than 1,800 acres will be disturbed by coal development and the County population will increase by seven percent over 1970 levels. Still, impacts on wildlife resources will be relatively small.

By the year 2000, coal development will have affected 6,171 acres. The County population will increase 17 percent over the 1970 level. Most of the development coincides with some of the better sage grouse habitat in the County. Probably the wildlife most affected will be several species of raptorial birds and, if it is present, the black-footed ferret, an endangered mammal. Most raptors will be lost through collisions with vehicles and through indiscriminate shooting. Ferrets are secretive inhabitants of prairie dog towns and none have been verified present in Montana in several years. Their continued presence in very low numbers in eastern Montana is suspected. Man's effect on black-footed ferrets would be caused by accidental road kills, poisons intended for prairie dogs and predators, and traps intended for furbearers and predators.

Hunting conditions will change moderately in the County by the year 2000. Presently the Crow Indian Reservation is closed to big-game hunting by non-tribal members, leaving only a small portion of the County open to hunting by the general public. However, better deer hunting is available to the east. Some Indian tribes in the region manage selective and lucrative big-game hunting enterprises for non-Indians on their reservations. It is possible the Crows will take greater advantage of the wildlife habitat their reservation provides and place greater emphasis on game management by the year 2000. Significantly more nearby big-game hunting opportunities would then be available to non-Indians.

An additional 344 County residents who fish are projected for the year 2000. Most of the additional fishing pressure will be directed toward the trout streams draining the Big Horn Mountains, such as Lodge Grass Creek, at the large reservoirs in the County, Yellowtail and Tongue River Reservoirs, and their tailwater fisheries and at small reservoirs. With the exception of the small trout streams, these fisheries can easily absorb the projected increase in fishing demand. Trout stream fishing conditions will change moderately, mainly by more restrictive fishing regulations.

2. Most probable forecast

In the Most Probable Forecast, by 1980 there will be minor habitat losses in Big Horn County, but impacts on fish and wildlife will be small.

By 1985, more than 4,800 acres in the County will be lost to coal development and the population will increase 17 percent. These impacts are roughly analogous to Base Forecast impacts for the year 2000. A notable difference is that in this forecast for 1985 some 1,200 acres of pheasant habitat will be destroyed. In Big Horn County pheasant habitat is restricted to a few river bottomlands; loss of 1,200 acres will be serious.

In the year 2000, coal development will have occupied or destroyed 14,200 acres of Big Horn County's wildlife habitat. More than 3,800 additional people will reside in the County--a 38 percent increase over 1970. Enough losses of raptors, deer, sage grouse, sharp-tailed grouse, ring-necked pheasant, turkey and waterfowl habitat will accrue to cause serious concern for the County's populations of these species. However, only demand on deer and sage grouse hunting, with projected increases of 914 and 304 hunters for those species, respectively, will exceed the County's ability to meet that demand. During recent seasons hunter success has been exceptionally high in the southeastern corner of the County. Many County residents will travel farther from the County to harvest those species.

A projected increase of 762 more people who fish residing in the County by the year 2000 will bring excessive fishing pressure on the trout streams of the Big Horn Mountains. A significant reordering of trout fishing regulations will likely occur in the area.

3. Extensive development forecast

Development projections for the Extensive Development Forecast in 1980 are 2,100 acres lost to coal development and a 12 percent increase in the County population. The only wildlife species whose habitat will be significantly adversely affected are those classified as threatened species. The black-footed ferret is an endangered species suspected but not confirmed to survive in southeastern Montana. Habitat of this species is abundant in Big Horn County. The American peregrine falcon, also an endangered species, is a spring and fall visitor to the County. This species has declined drastically in the past 30 years, primarily through man's use of chlorinated pesticides. Other man-caused mortality has contributed to the decline of this species. Human population increases in the County pose an additional threat to individual peregrine falcons overflying the County and taking prey from it.

Status-undetermined species who inhabit the County are primarily raptors. They include the ferruginous hawk, prairie falcon, prairie pigeon hawk, western burrowing owl, and American osprey, which is regularly observed at Yellowtail Reservoir. Nonraptors include the mountain plover, northern long-billed curlew, and the northern swift fox. The swift fox has not been observed in the County recently. Each of these species will be jeopardized by the increased presence of man.

Nesting golden and wintering golden and bald eagles inhabit the Big Horn and Pryor Mountains. Increased use of these areas by man will be detrimental to these species.

The pine martin, wolverine, and Canada lynx inhabit the less accessible areas of the Big Horn Mountains. Projected impacts on these species are minor.

Hunting for deer and sage grouse will change moderately in the County because of increased competition among hunters for these species. Fishing will be lightly affected.

By 1985 coal development will destroy 6,900 acres. The human population will increase 40 percent over 1970 levels. Serious losses of sage grouse and ring-necked pheasant habitat will occur. Almost 1,000 more deer hunters will compete for the limited area of the County open to non-Indian hunters. Many County residents will hunt deer and sage grouse out of the County. Fishing in the small mountain trout streams will be overcrowded and trout fishing regulations in the area will be far more restrictive.

In the yaar 2000, over 43,000 acres will be lost to coal development. The County's population will have more than doubled 1970 levels.

Losses of hunting grounds and interference by and direct mortality from man will affect many raptors significantly. For example, enough small mammal habitat to support seven wintering eagles will be lost.

The coal related developments projected for this time and scenario--aqueducts, railroads, highways, and transmission lines--coincide with some of the best deer habitat in the County. This will have disastrous impacts on local County deer populations. These developments also account for the only projected loss of antelope habitat in the County--7,465 acres. Unfortunately, this is some of the better antelope habitat in the County. This loss, although small, is serious.

Turkey habitat is restricted to small locales. Coal development will destroy 9,225 acres--a huge loss in the middle of the County's best turkey areas.

Serious habitat losses will affect sage and sharp-tailed grouse, ring-necked pheasant, waterfowl and small birds and mammals in the County. The development is projected in many species' best habitat in the County.

Hunting for deer in the County will be disastrously changed. A projected increase of 2,787 more deer hunters will compete for significantly less deer in the County and in Rosebud County to the east.

Hunting for most upland game species will be significantly changed in that there will be far more hunters competing with each other for access to private lands. A key issue in satisfying demand for nearby small game hunting is whether the Crow Indian Reservation continues to allow non-Indian small game hunting by permit.

The Big Horn River remains ice-free in the County throughout the winter and attracts thousands of overwintering ducks, primarily mallards, and some Canada geese to the County. This provides a significant hunting resource. A projected 290 additional waterfowl hunters residing in the County will overcrowd present hunting conditions which occur mostly in a narrow area along the river.

There will be a projected increase of 2,315 more people who fish residing in the County by the year 2000. They will overcrowd existing trout fisheries and seriously affect mixed cold and warm water fisheries which exist in the tailwaters of the County's major reservoirs.

C. Rosebud County, Montana

1. Base forecast

Rosebud County will lose 2,500 acres of high quality wildlife habitat to coal development by 1980. Impacts on most species will be minor.

By 1985 more than 5,800 acres will be lost and the County's population will increase by 400 over 1970. Impacts on wildlife will be minor.

In the year 2000 more than 15,000 acres will be destroyed by coal development. Some 1,000 more people will reside in the County than did in 1970. Impacts on wildlife will be small but most will be significant and some serious. The black-footed ferret and the American peregrine falcon may and do inhabit the County, respectively. Increased human occupancy of an area can only be detrimental to those species. Other raptors, some whose species' status is unknown, are abundant in the County. They will be adversely affected.

All of the habitat that will be lost is either good or medium quality deer habitat. Most is also medium quality antelope habitat. Sage and sharp-tailed grouse, Hungarian partridge, ring-necked pheasant, and numerous small mammals and birds are now abundant in those areas which will be destroyed by coal development. Because development coincides with some of the best deer habitat in the State, and with a significant portion of the limited pheasant habitat, losses to these species will be serious.

2. Most probable forecast

Losses of wildlife habitat by 1980 will be 2,500 acres. By 1985 more than 7,700 acres will be lost. The entire area projected for loss is good big game and upland game habitat and provides excellent habitat for a variety of small mammals--an important prey for wintering eagles--and small birds. However, only 1,000 more people will reside in the County than did in 1970. Impacts on wildlife and fishing will be minor, yet noticeable.

By the year 2000 coal development will affect 27,000 acres and the human population of the County will increase by 2,285, or 40 percent higher than in 1970.

All of the area is good or medium quality habitat for white-tailed and mule deer, sharp-tailed grouse, hawks, eagles and small mammals. Much of it is good or medium quality sage grouse, Hungarian partridge, ring-necked pheasant, cottontail rabbit, and small bird and mammal habitat. Much of it is also medium quality antelope habitat. Impacts on deer, sage and sharp-tailed grouse, and pheasants will be serious. Impacts on other species will be serious to small local populations but not to total County populations. Only deer hunting will be noticeably changed--by the projected increase of 585 more hunters than resided in the County in 1970. Competition among residents for a place to hunt could be mitigated by a reduction in the non-resident deer permits available in the County. Elimination of all non-resident deer hunting in the County would not be necessary.

3. Extensive development forecast

In 1980 more than 4,000 acres will be lost to coal development in Rosebud County. The entire lost area is good wildlife habitat supporting a variety of big game, upland game, and non-game birds and mammals. The acreage is small in relation to the County's total habitat value and impacts from this loss to County populations will be small.

By 1985 coal development will involve 14,000 acres. The County population will increase by 2,400 people, or 40 percent over 1970. All of the area destroyed by coal development is good or medium quality deer, sage grouse, sharp-tailed grouse, and Hungarian partridge habitat. It also serves as excellent habitat for eagles, hawks, passerine birds, and small mammals. Much of it is good or medium quality antelope, pheasant, and turkey habitat. However, only impacts on what endangered species that may be present, some eagles and hawks, nesting waterfowl, and deer will be serious. Deer hunting will be significantly changed by a projected increase of 585 more hunters residing in the County and competing with each other for hunting area and game animals.

By the year 2000, coal development will have destroyed almost 70,000 acres of wildlife habitat. The County population will be double 1970 levels. Impact on habitat of all species will be serious.

The best deer habitat in Rosebud County is in the southern portion. All development coincides with areas of the best deer habitat--this will be disastrous to County deer populations

Although 42,000 acres of good and medium quality antelope habitat will be lost, the County's best habitat is north of the Yellowstone River and will be unaffected by coal development. About 67,000 acres of sage grouse habitat will be lost but this species' best habitat also occurs north of the Yellowstone.

The best sharp-tailed grouse habitat coincides with development. The loss of 66,000 acres of good and medium quality sharptail habitat is serious but still small in relation to the County total.

The entire area destroyed is Hungarian partridge habitat. However, this exotic bird is not dependent on the natural prairie ecosystems and may benefit more than others from strip-mine rehabilitation efforts.

Most of the ring-necked pheasant habitat in the County is along the Yellowstone and Tongue River bottomlands. Projected railroads, highways, and aqueducts and some mining will destroy 30,000 acres of pheasant habitat--a disastrous loss to species with limited distribution in the County.

Development will destroy 17,000 acres in the two best areas of turkey habitat in the County--a very serious loss. Serious losses of streamside nesting habitat used by ducks, primarily mallards, will accrue.

Besides deer, raptors will be most adversely affected. Hunting for all other game species will be seriously affected by decreases in game animals, less access to private lands, increased competition with other hunters on public lands, and more restrictive hunting regulations.

A projected increase of 1,252 people who fish residing in the County will not seriously degrade existing fishing opportunity in the County. The Yellowstone River and the many farm and stock ponds in the County can meet greatly increased fishing pressure. Additionally, many County residents will travel to the west to fish reservoirs and trout waters.

D. Mercer-Oliver Counties, North Dakota

1. Base forecast

Mercer and Oliver Counties encompass about 1,127,000 acres and the 1970 human population totaled 8,500. The projected additional human population is 2,993 for year 1980, no change for year 1985, and 4,536 for year 2000. Land disturbance from coal mining activity will involve 1,276 acres in 1980, 4,676 acres in 1985, and 14,955 acres in the year 2000.

There are no indications of any additional railroads, transmission lines, or highway construction in regard to the Base Forecast. Likewise, it is presumed no aqueducts or impoundments are associated with this forecast. In 1980, two mines will be in operation in Mercer County and production will remain essentially constant to year 2000. One power generating plant will come on line in Mercer County in the year 2000. In Oliver County two mines will become operational in 1980 and remain essentially constant through to the year 2000.

The projected increase in human population of the two Counties is calculated to increase hunting demand by the following amounts:

Species or Group	Percent of Increase		
	1980	1985	2000
Deer	35	35	53
Antelope	35	35	53
Small game	36	36	54
Fish	35	35	53

The effects of the Base Forecast on several species and groups of wildlife are briefly summarized below.

Deer - Habitat value is rated at about 14 percent high, 75 percent medium (157,780 acres and 845,250 acres, respectively), and the remainder is low value. Perhaps 30 to 35 sections of high value habitat are situated in strippable coal areas. Considering the several known factors it is believed that projected 1980 development will result in minimal adverse impact on deer habitat. Projected 1985 and year 2000 development will result in somewhat greater adverse impacts. Generally the area of disturbance is not great in relation to existing habitat. Adverse impacts on deer hunting will also result from 1980 and 1985 development estimates. More serious concern is felt for year 2000 development projections. Basically, deer hunting opportunity cannot presently meet demand and any additional demand reduces existing quantity and quality.

Antelope - Habitat value is classed at about 10 percent high and 80 percent medium (104,000 acres and 918,000 acres, respectively). It is believed that projected 1980 and 1985 development will have minor adverse impacts on antelope habitat in Mercer and Oliver Counties. More serious concern is felt about the year 2000 projection. The amount of disturbed land is minor in relation to the total sample area. We believe antelope hunting will suffer only slight adverse impacts from projected 1980, 1985 and year 2000 base development. There is a small antelope herd in the sample counties; however, public hunting is nonexistent. Few permits are issued and these only to landowners. Additional hunting demand would have little impact on that system.

Sharp-tailed grouse - The sample area is rated as 100 percent high value grouse habitat. Projected development for the years 1980, 1985, and 2000 are expected to have minor adverse impact. Generally, the amount of disturbed land is minor in relation to the total habitat acreage. Hunting is likewise not expected to suffer more than minor adverse effects for years 1980, 1985, and 2000, Base Forecast. Sharp-tailed grouse are one of the few game species currently underharvested. Also, they are wary and resourceful birds requiring considerable effort to bag, thus discouraging overkill.

Hungarian partridge - Habitat value is classed at about 85 percent high and 15 percent medium (957,500 acres and 169,500 acres, respectively). Although most projected mining activity for the years 1980, 1985, and 2000 appears to be located in high value habitat, adverse impacts on habitat are generally believed to be minor. This conclusion is attributed to the relatively large amount of undisturbed habitat in relation to that disturbed. Hunting will be adversely affected by the Base Forecast for years 1980 and 1985. For the year 2000, serious concern is felt for quality and quantity of hunting opportunity. The Hungarian partridge is not as adept at withstanding significant increases in hunting demand as are some native species.

Ring-necked pheasant - The area is rated at 10 percent high value habitat and 90 percent medium value (112,700 acres and 1,014,300 acres, respectively). Because only a small amount of habitat will be disturbed in relation to total amount we conclude that only modest adverse impacts will be forthcoming for the projected Base Forecast for years 1980, 1985, and 2000. Impact on hunting will be strongly adverse for years 1980 and 1985. By year 2000 the impact will be of serious concern. The pheasant receives exceptional attention from hunters and a 54 percent increase in hunters will put a considerable strain on the harvestable population.

Turkey - There is no high value habitat in the two Counties. There are about 139,400 acres of habitat rated medium in value, of which approximately 8,000 acres lie over strippable coal. The remainder (131,400 acres) will apparently remain undisturbed according to the Base Forecast data. For this reason we believe effects on turkey habitat for the years 1980, 1985, and 2000 will be only moderately adverse. The statewide over-winter turkey population has fluctuated from around 1,900 to about 500 birds in recent years. Through 12 recent hunting seasons an average of about 150 turkeys have been legally killed. About 200 permits are sold annually in the entire State. Since the sample area provides only a small part of this small amount of hunting opportunity almost any increase in demand will have major impact on quality and quantity. We believe impacts on turkey hunting for the years 1980, 1985, and 2000 will be a serious concern.

Waterfowl (ducks, geese, swans, and cranes) - Oliver and Mercer Counties are considered to provide all medium value habitat with the exception of lands adjacent to the Missouri River which are rated as high value. There is no significant amount of whistling swan usage west of the Missouri River, therefore, the sample area is considered low value swan habitat. The area does not constitute a good waterfowl production or migration area relative to other parts of the State. Most surface waters are stock ponds and the Knife River. Since mining will affect an unknown number of stock ponds of moderate to low value, and according to the Base Forecast the amount of disturbed land is relatively minor, we conclude that relatively minor adverse impacts will occur. Swans are not hunted and cranes are legal game only east of the Missouri River outside the sample area. Duck and goose hunting is limited in the sample area to rivers and stock ponds. Because duck and goose hunting opportunities in Oliver and Mercer Counties are minimal and presently well utilized any additional demand on the local resource will result in a relatively severe impact on quality and quantity.

Raptors - The mobility of raptors may reduce to a considerable extent the detrimental effects of land disturbance. Eagles, hawks, and owls can avoid disturbed areas until such areas are again usable. The main threats to raptors probably include shooting, pesticide-induced reproductive failure, heavy metal contamination (stack emissions), and nest molestation. These threats are primarily related to human population rather than land disturbance. Based on available data we conclude moderate adverse impacts will result under Base Forecast conditions.

Passerine species - Probably the greatest detrimental impact will result from loss of habitat. Reclamation, if successful, should provide liveable conditions for some bird species - if not those now present. Although the Base Forecast does not indicate any additional transmission lines or aqueducts, we believe these facilities are still a possibility and may cause some mortality. Predicted human population increases will cause some mortality by such factors as increased vehicle traffic, pets, and nest molestation. However, since most perching birds are seldom deliberately destroyed by humans, overall impact will probably be of a minor adverse nature.

Threatened and "status-undetermined" species - Members of these groups which might conceivably be encountered in the sample area include several falcons and the whooping crane in the first category. The "status-undetermined" category may include pallid sturgeon in the Missouri River adjacent to the sample area, ferruginous hawk, American osprey, prairie pigeon hawk, eastern pigeon hawk, mountain plover, northern long-billed curlew, western burrowing owl, and northern swift fox. Disturbed acreage and increases in human population are likely to have detrimental effects on these two groups. We believe these effects will range from severe adverse impact status to a situation of serious concern.

Fish - Several data gaps are evident in making the coal impact evaluations. Most notable data lacking are those on: stack emissions, strip mining, right-of-ways, new reservoirs, increased human populations, and new roads, and their direct effect on water quality and existing fisheries. Also, data on water priorities and uses are lacking and their consequent effect on the fisheries.

At present, Federal and State hatcheries are operating at full capacity to meet stocking requests. Additional demands could not be met by existing facilities.

We are assuming our present fishery is maintained largely through hatchery produced fish. Any additional hatchery demands could result in adverse effects. We believe the projected Base Forecast will result in impacts ranging from severe adverse to serious concern through the three time frames.

2. Most probable forecast

The projected additional increase in human population is 2,993 for year 1980, 9,201 for 1985, and 21,086 for year 2000. Total land disturbance from coal mining activity will involve 1,376 acres in 1980, 6,563 acres in 1985, and 30,320 acres in the year 2000.

In 1980, four mines will be in operation with an assumed constant production through the year 2000. In 1985, one power generating plant will come on line in Mercer County. In 2000, an additional power plant and a gasification plant will come on line in Mercer County, and a power generation plant will come on line in Oliver County.

The projected increase in human population of the sample area is calculated to increase hunting demand by the following amounts:

Species or Group	Percent of Increase		
	1980	1985	2000
Deer	35	108	248
Antelope	35	108	248
Small game	36	110	251
Fish	35	108	248

The effects of the above conditions in the Most Probable Forecast on several species and groups of wildlife are briefly summarized below.

Deer - Habitat value is rated at 14 percent high and 75 percent medium (157,780 acres and 845,250 acres, respectively). The remainder is low value. Approximately 30 to 35 sections of high value deer habitat are situated over strippable coal. Considering the known factors it is believed that projected 1980 development will result in minimal adverse impact on deer habitat. Somewhat greater adverse impact is projected for 1985 but until the year 2000 it is not considered of serious concern. The area of disturbed habitat is not great in relation to the total.

Adverse impacts on deer hunting are expected for all time frames. Basically, deer hunting opportunity cannot meet present demand. Any additional demand reduces existing quantity and quality. By the year 2000, a 248 percent increase in hunters is considered to be of serious concern.

Antelope - Habitat value is classed at about 10 percent high and 80 percent medium (104,000 acres and 918,000 acres, respectively) with the remainder low value. All Most Probable Forecast mining is in high or medium habitat. Generally, it is believed that projected 1980 and 1985 development will have minor adverse impacts on antelope habitat since the amount of disturbance is small when compared to the total.

However, by the year 2000 with 30,320 acres of disturbance and a human population increase of 248 percent (21,086), there is reason for serious concern.

Antelope hunting opportunities are presently limited. Few permits are issued and permits usually go to landowners with public hunting nonexistent. Additional human population with additional hunters would have little effect upon public hunting until the year 2000. At this time the loss of habitat is significant as are other factors and a reduction in antelope numbers and huntable surplus is bound to occur.

Sharp-tailed grouse - The sample area is considered to be 100 percent high value sharp-tailed grouse habitat. Projected coal development for the three time frames is expected to have a minor adverse impact upon grouse habitat since the amount disturbed is small in relation to total habitat acreage.

Grouse hunting is likewise not expected to suffer more than minor adverse impacts for the three time frames. The bird is wary and resourceful requiring considerable effort to bag. It is presently underharvested in some areas so it is believed capable of absorbing some additional hunting pressure with little loss of hunting quality or danger of overkill.

Hungarian partridge - Partridge habitat is classed at about 85 percent high value and 15 percent medium value (957,500 acres and 169,500 acres, respectively). All of the coal mine activity lies within the high value habitat area. However, because of the relatively small amount of mine disturbance when compared to total habitat acreage, over the three time frames; we do not rate habitat disturbance to be of serious concern until the year 2000, when 30,320 acres are affected.

Hunting will be adversely affected in 1980, but does not reach serious concern until 1985 when 110 percent more hunters are projected (1970, 775 hunters and 1985, 1,583 hunters). By the year 2000, these factors, hunters up 251 percent to 2,653, habitat disturbance of 30,320 acres, and others, will have a disastrous impact upon quality and quantity of partridge hunting opportunity. Further restrictions will be necessary to maintain this species.

Ring-necked pheasant - Habitat in the sample area is rated 10 percent high value and 90 medium value (112,700 acres and 1,014,300 acres, respectively). Since only a small amount of habitat will be disturbed in relation to the total amount, we conclude that only modest adverse impacts will be forthcoming for the years 1980 and 1985 of the Most Probable Forecast. However, by the year 2000 with 30,320 acres of habitat disturbed, adverse impacts will have reached serious concern.

Impact upon pheasant hunting will be adverse in 1980, of serious concern in 1985, and will reach disastrous proportions by the year 2000. The ring-necked pheasant is an exotic, gaudy bird that receives exceptional attention and preference by hunters. It cannot withstand a 251 percent increase in hunters without severe harvest restrictions which would considerably lessen opportunity, quality, and quantity of the hunt.

Turkey - The only turkey habitat in the two-county area is 139,400 acres rated medium value. Approximately 8,000 acres or 12 percent lies over strippable coal all of which is involved in mining and will be either disturbed or adjacent to mining disturbance. The rest (131,400 acres) will apparently remain undisturbed. Due to the relatively small amount of disturbed habitat, we feel the adverse impact will be only moderate over the three time frames.

Turkey hunting will be affected to a more serious degree. Since the sample area provides only a small amount of hunting opportunity for a small turkey population almost any increase in demand upon it will have a major impact on hunting quality and quantity. Impacts upon turkey hunting for the years 1980 and 1985 will be of serious concern and will approach disastrous impact for the year 2000.

Waterfowl - Oliver and Mercer Counties are considered to provide all medium value habitat with the exception of lands adjacent to the Missouri River which are rated high. The sample area is considered low value swan habitat since there is no significant amount of swan usage west of the Missouri River. These Counties are not considered good duck production or migration habitat Counties relative to that portion of North Dakota east and north of the Missouri River. Most surface waters are found in stock ponds and streams of the Knife River drainage. Mining will disturb an unknown amount of this water and we conclude, that adverse impacts to habitat will be relatively minor in all time frames.

Impact upon available waterfowl hunting will be more severe. Because habitat is limited and migration use of available habitat is less than elsewhere. duck and goose hunting opportunities are minimal and well utilized. Additional demands on the local resource will result in serious adverse impacts in 1985 and approach disaster proportions by the year 2000 on hunting quality and quantity.

Raptors - The mobility of raptors may reduce to a considerable extent the detrimental effects of land disturbance. Eagles, hawks, and owls can avoid disturbed areas until such areas are again usable. The main threats to raptors probably include shooting, pesticide-induced reproductive failure, heavy metal contamination (stack emissions), and nest molestation. These threats are primarily related to human populations rather than land disturbance. Based on available data, we conclude moderate adverse impacts will occur under Most Probable Forecast conditions.

Passerine species - Probably the greatest detrimental impact will result from loss of habitat. Reclamation, if successful, should provide liveable conditions for some bird species - if not those present. Although the Most Probable Forecast does not indicate any additional transmission lines or aqueducts, we believe these facilities are a possibility and may cause some mortality. Predicted human population increases will cause some mortality from such factors as increased vehicle traffic, pets, and nest molestation. However, since most perching birds are seldom deliberately destroyed by humans, overall impact will probably be of a minor adverse nature.

Threatened and "status-undetermined" species - Members of these groups which might conceivably be encountered in the sample area include several falcons and the whooping crane in the first category. The "status-undetermined" category may include the pallid sturgeon in the Missouri River, ferruginous hawk, American osprey, prairie pigeon hawk, eastern pigeon hawk, mountain plover, northern long-billed curlew, western burrowing owl, and northern swift fox. Disturbed acreage and increases in human population are likely to have detrimental effects on these two groups which are already in trouble. We believe that, in the time frames of the Most Probable Forecast, these adverse impacts will all be of serious concern.

Fish - Several data gaps are evident in making impact evaluations. Most notable data lacking are those on: stack emissions, strip mining, right-of-ways, new reservoirs, increased human populations, and new roads, and their direct effect on water quality and existing fisheries. Also, data on water priorities and uses are lacking and consequent effect on the fisheries.

At present, Federal and State hatcheries are operating at full capacity to meet stocking requests. Any additional demands could not be met by existing facilities. Any additional hatchery demands could result in adverse effects. We believe that the projected Most Probable Forecast will result in adverse impacts ranging from serious concern in 1980 to disastrous in 1985 and 2000.

3. Extensive forecast

The projected additional human population is 15,425 for year 1980, 27,857 for year 1985, and 53,376 for year 2000. Land disturbance from coal mining activity will involve 5,050 acres in 1980, 17,407 acres in 1985, and 64,785 acres in the year 2000.

There are no indications of any additional railroads, transmission lines, or highway construction in regard to the Extensive Forecast. Likewise, it is presumed no impoundments are associated with this forecast. There are 47 miles of aqueduct planned for Mercer and Oliver Counties. A 200-foot wide construction strip associated with initial construction will involve 1,140 acres. A life-of-the-project maintenance trail will involve 170 acres.

In 1980, two mines will be in operation in Mercer County and production will remain essentially constant to the year 2000.

In 1980, two gasification plants, in 1985, one gasification plant and in the year 2000, two gasification plants will come on line in Mercer County, plus one power generating plant coming on line in year 2000.

In 1980, two mines will be in operation in Oliver County and production will remain essentially constant through year 2000. In year 2000, one power generating will come on line in Oliver County, plus one export mine coming on line in year 2000.

The projected increase in human population of the sample area is calculated to increase hunting demand by the following percentage amounts:

Species or Group	Percent of Increase 1980	1985	2000
Deer	181	328	628
Antelope	181	328	628
Small game	184	332	636
Fish	182	328	628

The effects of the Extensive Forecast on several species and groups of wildlife in Mercer and Oliver Counties, North Dakota, are briefly summarized below.

Deer - Habitat value is rated at about 14 percent high and 75 percent medium (157,780 acres and 845,250 acres, respectively), the remainder is low value. Perhaps 30 to 35 sections of high value deer habitat are situated in strippable coal areas. Considering the several known factors it is believed that projected 1980 development will result in minor adverse impact on deer habitat. Projected 1985 development will result in impacts of serious concern. We believe disastrous impacts will result from predicted forecasts for year 2000. Several factors generated by land disturbance will be hard on deer. Disastrous adverse impacts on deer hunting will also result from 1980, 1985 and year 2000 development estimates. Basically, deer hunting opportunity cannot presently meet demand and any additional demand reduces existing quantity and quality. Demand increases are significant for each time frame under the Extensive Forecast.

Antelope - Habitat is classed at about 10 percent high value and 80 percent medium value (104,000 acres and 918,000 acres, respectively). It is believed that projected 1980 and 1985 development will have major adverse impacts on antelope habitat in Mercer and Oliver Counties. Disastrous impacts are predicted for the year 2000 projection. Several factors generated by land disturbance will be hard on antelope. It is believed antelope hunting will suffer only slight adverse impacts from projected 1980 and 1985 development. There is a small antelope herd in the sample counties; however, public hunting is disallowed. Generally, few permits are issued and these only to landowners. Additional hunting demand would have little impact on that system so long as additional demand is not too great. For the year 2000, however, the increase in population is so large that serious concern for the resource is unavoidable.

Sharp-tailed grouse - The two-county sample area is rated as 100 percent high value grouse habitat. Projected development for the years 1980 and 1985 are expected to have minor adverse impact. Projected development for year 2000 will result in serious concern. Generally, the amount of disturbed land is minor in relation to the total habitat acreage except for year 2000 when it reaches significant proportions. Hunting is not expected to suffer more than minor adverse effects for years 1980, 1985, and 2000, Extensive Forecast. Sharp-tailed grouse are one of the few game species currently underharvested. Also, they are wary and resourceful birds requiring considerable effort to bag, thus discouraging overkill.

Hungarian partridge - Habitat is classed at about 85 percent high value and 15 percent medium value (957,500 acres and 169,500 acres, respectively) in the sample area. Projected development for year 1980 will have moderate adverse impacts on habitat. The year 1985 development forecast causes serious concern and the year 2000 will be disastrous. These conclusions are due to a relatively large amount of disturbed habitat, including several ancillary side effects of a detrimental nature predicted for the three time frames. Hunting quality and quantity will be disastrously affected for years

1980, 1985, and 2000. Hungarian partridges are not as adept at withstanding significant increases in hunting demand as are some native species - for example, the sharp-tailed grouse. Human population projections with resultant increases in hunter demand are significant for each of the three time frames.

Ring-necked pheasant - The sample area is rated at 10 percent high value habitat and 90 percent medium value (112,700 acres and 1,014,300 acres, respectively). Projected development for year 1980 will have a moderate adverse impact on pheasant populations. Development for the year 1985 will reach a situation of serious concern. The year 2000 projection will result in disastrous impacts on pheasant habitat. Impact on hunting will be disastrous for years 1980, 1985, and 2000. The pheasant receives exceptional attention from hunters and the percent increase in hunters for three time frames will strain harvestable surpluses to the maximum.

Turkey - There is no high value habitat in the sample area counties. There are about 139,400 acres of habitat rated medium value, of which approximately 8,000 acres lie over strippable coal. The remainder (131,400 acres) will apparently remain undisturbed for the year 1980 forecast. For this reason we believe effects on turkey habitat for that time frame will be only moderately adverse. With the disturbance predicted for 1985 we feel serious concern and disturbance anticipated for year 2000 will in our opinion result in disastrous effects. The statewide over-winter turkey population has fluctuated from around 1,900 to about 500 birds in recent years. Through 12 recent hunting seasons an average of about 150 turkeys have been legally killed. About 200 permits are sold annually in the entire State. Since the sample area provides only a fraction of this small amount of hunting opportunity almost any increase in demand upon it will have extensive impact on quality and quantity. We believe impacts on turkey hunting for the years 1980, 1985, and 2000, will be disastrous based on calculated increases in hunter demand.

Waterfowl (ducks, geese, swans and cranes) - Oliver and Mercer Counties are considered to provide all medium value habitat with the exception of lands adjacent to the Missouri River which are rated as high value. There is no significant amount of whistling swan usage west of the Missouri River, therefore, the sample area is considered low value swan habitat. These Counties do not constitute a good waterfowl production or migration area relative to other parts of the State. Most surface waters are stock ponds and the Knife River. Because mining under the Extensive Forecast will probably affect a considerable number of stock ponds of low to moderate value, we believe that relatively severe adverse impacts will occur. Swans are not hunted and cranes are legal game only east of the Missouri River outside the sample area. Duck and goose hunting is limited in the sample area to rivers and stock ponds. Because duck and goose hunting opportunities in Oliver and Mercer Counties are minimal and are presently well utilized, the additional demand on the local resource suggested by Extensive Forecast population projections will result in disastrous impacts on existing hunting quality and quantity.

Raptors - The mobility of raptors may reduce considerably the detrimental effects of land disturbance on that group. Eagles, hawks, and owls may avoid disturbed areas until such areas are again usable. The main threats to raptors probably include shooting, pesticide-induced reproductive failure, heavy metal contamination (stack emissions), and nest molestation. These threats are primarily related to human populations rather than land disturbance. Based on available data primarily human population projections, we conclude impacts will vary from strongly adverse to disastrous under Extensive Forecast conditions.

Passerine species - Probably the greatest detrimental impact will result from loss of habitat. Reclamation, if successful, should provide liveable conditions for some bird species - if not those now present. Although the Extensive Forecast does not indicate any additional transmission lines in the sample area we believe these facilities are still a possibility and may cause some mortality. Surge towers associated with aqueducts also pose a flight hazard to birds. Predicted human population increase will also cause some mortality from such factors as increased vehicle traffic, pets, and nest molestation. However, most perching birds are seldom deliberately destroyed by humans. In our opinion overall impact will probably be of a moderate adverse nature.

Threatened and "status-undetermined" species - Members of these groups which might conceivably be encountered in the sample area include several falcons and the whooping crane in the first category. The "status-undetermined" category may include pallid sturgeon in the Missouri River adjacent to the sample area, ferruginous hawk, American osprey, prairie pigeon hawk, eastern pigeon hawk, mountain plover, northern long-billed curlew, western burrowing owl, and norther swift fox. Disturbed acreage and increases in human population are likely to have detrimental effects on these two groups. We believe impact effects will range from serious concern to disastrous proportions.

Fish - Several data gaps are evident in making the coal impact evaluations. Most notable data lacking are those on: stack emissions, strip mining, right-of-ways, new reservoirs, increased human populations, and new roads, and their direct effect on water quality and existing fisheries. Also, data on water priorities and uses are lacking and consequent effect on the fisheries.

At present, Federal and State hatcheries are operating at full capacity to meet stocking requests. Any additional demands could not be met by existing facilities.

We are assuming our present fishery is maintained largely through hatchery produced fish. Any additional hatchery demands could result in adverse effects. We believe the projected Extensive Forecast will result in disastrous impacts through the three time frames.

E. South Dakota

No development of coal reserves in South Dakota is indicated by information available to the Subgroup on Fish and Wildlife Resources. Some facilities ancillary to coal development in Wyoming, Montana, and North Dakota will be constructed in South Dakota. These will likely include transmission lines and railroads. The limited facilities as proposed for South Dakota will have some local adverse impacts on fish and wildlife, but will be of minimal significance on a regional basis.

Wildlife impacts in South Dakota incidental to coal development in bordering states are conjectural and difficult to evaluate. Increased transportation of people, equipment, materials and energy products, increased populations, and facility stack emissions will each have an impact; but, it will be a relatively unpredictable impact because of the lack of historical background, research, and experience with this type and projected magnitude of development in the plains area.

Prevailing winds of the projected coal development area place South Dakota downwind from essentially all contemplated power and gas production facilities. For this reason, airborne stack emissions are considered to be the primary concern for adverse impacts on fish and wildlife in this State.

VII. EXPLANATION OF PROCEDURES

The impacts on fish and wildlife resources projected in this report are based on subjective judgments of the subgroup's biologists. Subjective decisions of what may occur were based on a thorough review of the following: (1) basic data provided the subgroup by the Surface Resources Work Group Leader, (2) adherence to Basic Assumptions of the Surface Resources Work Group plus formulation of additional assumptions by the subgroup, (3) mapping development data and some fish and wildlife data at a scale of 1:1,000,000, and (4) compilation of matrices which arrayed magnitude and degree of impacts.

Basic data provided the subgroup projected data for three time frames (1980, 1985, and 2000) and three scenarios (Base Forecast, Most Probable Forecast, and Extensive Development Forecast). Wherever subgroup members are reasonably certain a projected development would cause a described impact on a fish and wildlife resource the adverb "will" modifies the verb. Adverbs reflecting uncertainty--may, could, etc.--are used and underlined for emphasis wherever there is reasonable doubt what impact from projected development would occur.

A. The following basic data were provided the Surface Resources Work Group:

Table 1. "Quantified mining activities for the base, most probable, and extensive development forecasts for the four selected sample areas."

Table 2. "Quantified mining activities for the base, most probable, and extensive development forecasts in counties other than the selected sample areas."

Table 2a. (Supplemental).

Population basic data provided by Socioeconomics Work Group.

Water development data for the year 2000, Extensive Development Forecast, provided by Water Resources Work Group.

Using data in the tables subgroup members calculated acres required/consumed/destroyed by each mine or plant site for the three time frames of each scenario. In some instances, acreages were also calculated for the years 2020 and 2025. Using the maps prepared by the Mineral Resources Work Group, the coincidence of a particular mine or plant site with high, medium, and low quality, key, or zero habitat for each species mapped was noted. Acreages of good and medium quality habitat (for turkey and big game other than deer and antelope, low quality habitat was also included) lost for each species was totaled for each time frame and scenario. Those totals are shown in tables in accompanying Appendix I. Considering the map scale used, the reader must not infer that the designated site actually provides the quality or acreage of habitat this method determined. However, for a regional picture, the figures may be construed as a reasonable accurate assumption, of acres of habitat lost.

Development data for highways, railroads, aqueducts, reservoirs, and transmission lines projected for the year 2000, extensive development scenarios, were curdely enlarged from an 8-1/2" x 11" map to a 36 x 36" overlay (scale 1:1,000,000) and the habitat losses calculated for each mapped species. This was done only for Montana and Wyoming; sufficient background data were not available to extrapolate these data to the Dakotas.

Population projections for all states except Montana were used intact. Montana projections provided the subgroup were not divided by county, but rather applied to an aggregate of seven counties. From these data the rates of increase over 1970 levels were calculated, and those rates applied to 1970 population levels for Big Horn and Rosebud Counties.

Projected increases in numbers of hunters and people who fish residing in a sample area and the region were projected based on rates of statewide participation in that activity in 1970 times the projected population increases. Table 5 shows rates of participation in types of hunting and fishing by residents and lists sources of those rates.

One may speculate that participation rates in various hunting and fishing activities will increase because most trends have been toward greater participation and increased mobility and leisure time, or that rates will decrease because of a finite resource, a greater urban population, gas rationing, etc. Many of the figures used in Table 5 are rough approximations and were compiled to allow subgroup members to compare projected demands on the resource with present demand.

Table 5.--Rates as a percentage of total state population of participation in types of hunting and in fishing by residents.

			North Dakota 3/	
Species Hunted	Montana 1/	Wyoming 2/	28 Western Counties	Oliver and Mercer Co's
Deer	24	20	9 4/	5
Antelope	3	7	1 5/	-
Elk	11	14	-	-
Sage grouse	8 6/	7	-	-
Sharp-tailed grouse	8	1	12 6/	9 6/
Hungarian partridge	8	3	12	9
Ring-necked pheasant	8	9	12	9
Turkey	0.2 7/	1	-	-
Waterfowl	2.5 8/	-	12	9
Ducks	2.4	5	-	-
Geese	1.2	3	-	-
Fishing	20	39 9/	13	24

1/ Adapted from Montana Department of Fish and Game, 1972, p. 38.

2/ Source: Doll and Phillips, 1970 (Table III-1).

3/ Rates based on actual number of resident hunting and fishing permits issued in 28 western counties and Oliver and Mercer Counties in 1970.

4/ Based on statewide rather than 28 county resident participation.

5/ In 1970, 7,700 residents applied for 6,700 permits.

6/ All small game hunting combined.

7/ 1969 data adapted from Mussehl and Howell, 1971.

8/ From page 3, Montana Department of Fish and Game, Waterfowl Harvest Survey, June 1, 1972.

9/ From Table III-1 (Doll and Phillips, 1970) 39% fished lakes or reservoirs, 36% fished streams.

In evaluating impacts on the present hunting situation for each species, the following factors were considered:

1. Decrease in number of game animals where losses would occur only as a result of significant habitat losses due to coal development.

2. Increase in resident hunters. Any increase in numbers of resident hunters is considered detrimental to hunting conditions experienced by present hunters.

3. Decrease in non-resident hunters. Any decrease in non-resident hunters, projected as a result of competition with resident hunters, is considered detrimental to the present situation.

4. Increase in access problems. Development of public lands will increase access to some areas--considered favorable to hunting. Other development will restrict entry to former public lands--considered detrimental. Any increase in hunter numbers is considered detrimental to public access to private lands.

5. Decrease in success ratio. Where hunting is not restricted to specially drawn permits, the hunter success ratio is expected to decrease when numbers of hunters increase and game animal habitat and numbers decrease.

6. Decrease in quality of hunt. This depends on the above factors plus esthetic characteristics of hunting. For example, for some hunters quality of the hunt for plains animals (deer, antelope, native prairie grouse) deteriorates when transmission lines, aqueduct surge towers, and other developments interrupt otherwise undisturbed rangeland vistas.

B. Thirteen Basic Assumptions were provided the Surface Resources Work Group. Assumption No. 12 provides that a minimum of 25 years is required to restore reclaimed wildlife habitat to predisturbance habitat quality. The Fish and Wildlife Subgroup accepted this assumption because (1) for some species, particularly exotic upland game, habitat restoration will occur within a very few years; while on the other hand, (2) for other species the habitat restoration period may require 50 to 150 years or even longer to provide the variety of forage species used in an animal's diet.

The subgroup also made and adhered to this additional assumption:

> 14. Assume the impacts from development disturbance on wildlife species, and on the ecosystems they are part of, will not occur in a linear relationship and will have an influence beyond defined siting boundaries.

This assumption attempts to account for non-quantifiable impacts of behavior disturbance and possibly, noise and threshhold concepts, whereby a population is reduced to a point where it is no longer viable, although enough habitat for some individuals remains.

C. The maps depicting wildlife habitat and wildlife and fish distribution appended to the Regional Profile Report in page size (8 x 10½") were drafted at a scale of 1:1,000,000; size 36" x 36", on clear mylar. The originals serve as overlays to determine coincidence of development with habitat and were referred to extensively during the analysis of impacts.

D. Eight different matrices were prepared which arrayed, compared, and weighted impacts on wildlife species' habitat. For game animals impacts on hunting were also rated factors. Acres of lost habitat were arrayed in a "magnitude" line and the significance of the impact rated on a scale of +9 through -9, where +9 equals the best possible change, -9 equals the worst possible change, and 0 indicates no change or impact. Significantly, the subgroup's matrices indicated no positive changes projected in the analysis and very few zero impacts. In rating negative impacts from -1 through -9, the subgroup did not follow linear relationships but rated within three categories of negative impacts where -1 through -3 indicated some adverse impact, -4 through -6 indicated sufficient adverse impact to cause serious concern, and -7 through -9 indicated a disastrous change in the resource from present conditions. Much of the data arrayed in the matrices are presented in condensed form in Tables 6 through 22, Appendix I.

Game species are treated in greater detail than are non-game species in this impact analysis simply because far more is known about populations of game species in the region. This is a reflection of management decisions of the past, legislated responsibilities and the fact that hunting license fees pay most of the costs of wildlife management. A rapid trend toward management of non-game species nationwide is also occurring in the study area. Most of the species considered in the analyses were game animals, selected as those most common to the study area. Unless specifically noted otherwise, all references to deer collectively refer to both mule and white-tailed deer.

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APPENDIX I
Tables of Projected Habitat Losses

Table 1.--Acres of Projected Habitat Losses to Coal Development in the NGPRP Study Area in the Base Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	6,370	17,061	51,359
Antelope	5,478	14,914	44,227
Other Big Game	167	257	527
Sage Grouse	3,602	8,647	23,896
Sharp-tailed Grouse	5,538	14,329	42,898
Hungarian Partridge	5,116	13,287	39,270
Ring-necked Pheasant	3,811	10,702	31,883
Turkey	826	1,976	5,939
Total Habitat	6,583	17,354	51,931

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include Low quality habitat.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 2.--Acres of Projected Habitat Losses to Coal Development in Campbell County, Wyoming, in the Base Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	832	2,732	9,033
Antelope	1,045	3,025	9,033
Other Big Game	0	0	0
Sage Grouse	248	728	2,167
Sharp-tailed Grouse	0	0	0
Hungarian Partridge	0	0	0
Ring-necked Pheasant	0	0	0
Turkey	0	0	0
Total Habitat	1,045	3,025	9,033

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 3.--Acres of Projected Habitat Losses to Coal Development in Big Horn County, Montana, in the Base Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	626	1,806	6,171
Antelope	0	0	0
Sage Grouse	626	1,806	5,827
Sharp-tailed Grouse	626	1,806	6,171
Hungarian Partridge	626	1,806	6,017
Ring-necked Pheasant	0	0	0
Turkey	201	461	1,241
Total Habitat	626	1,806	6,171

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 4.--Acres of Projected Habitat Losses to Coal Development in Rosebud County, Montana, in the Base Forecast 1/

Species	Year 1980	1985	2000 2/
Deer 3/	2,561	5,856	15,375
Antelope	2,561	5,856	14,941
Sage Grouse	2,561	5,856	15,375
Sharp-tailed Grouse	2,561	5,856	15,375
Hungarian Partridge	2,561	5,856	15,375
Ring-necked Pheasant	1,939	4,669	12,239
Turkey	0	0	434
Total Habitat	2,561	5,856	15,375

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 5.-- Acres of Projected Habitat Losses to Coal Development in Oliver and Mercer Counties, North Dakota, in the Base Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	1,276	4,676	14,955
Antelope	1,276	4,676	14,955
Sharp-tailed Grouse	1,276	4,676	14,955
Hungarian Partridge	1,276	4,676	14,955
Ring-necked Pheasant	1,276	4,676	14,955
Turkey	458	1,258	3,737
Total Habitat	1,276	4,676	14,955

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 6.-- Subjective Evaluation of Significance of Losses shown in Tables 1, 2, 3, 4, and 5 (Base Forecast)

		Deer	Antelope	Other Big Game	Sage Grouse	Sharp-tailed Grouse	Hungarian Partridge	Ring-necked Pheasant	Turkey	Total Habitat
NGPRP Study Area	1980	A	A	A	A	A	A	A	A	A
	1985	A	A	A	A	A	A	A	A	A
	2000	A	A	A	A	A	A	A	S	A
Campbell Co.,Wyo.	1980	A	A	O	A	A	A	O	O	A
	1985	A	A	O	A	A	A	O	O	A
	2000	S	S	O	A	A	A	O	O	A
Big Horn Co.,MT.	1980	A	A	O	A	A	A	O	A	A
	1985	A	A	O	A	A	A	O	A	A
	2000	A	A	O	S	A	A	O	A	A
Rosebud Co., MT.	1980	A	A	O	A	A	A	A	O	A
	1985	A	A	O	A	A	A	A	O	A
	2000	S	A	O	A	A	A	S	A	A
Oliver and Mercer Counties,N.D.	1980	A	A	O	O	A	A	A	A	A
	1985	A	A	O	O	A	A	A	A	A
	2000	A	S	O	O	A	A	S	A	A

O - Little or no impact.
A - Some adverse impact.
S - Serious losses.
M - Major losses, some of disastrous proportions.

Table 7.-- Acres of Projected Habitat Losses to Coal Development in the NGPRP Study Area in the Most Probable Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	6,141	24,346	91,523
Antelope	5,259	20,548	73,662
Other Big Game	167	257	527
Sage Grouse	3,802	16,127	50,111
Sharp-tailed Grouse	5,309	20,018	75,813
Hungarian Partridge	4,887	18,974	69,784
Ring-necked Pheasant	3,381	12,771	52,833
Turkey	826	1,976	10,509
Total Habitat	6,565	26,419	95,462

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 8.-- Acres of Projected Habitat Losses to Coal Development in Campbell County, Wyoming, in the Most Probable Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer3/	832	3,004	11,370
Antelope	1,256	5,077	15,918
Sage Grouse	248	728	2,167
Sharp-tailed Grouse	0	0	0
Hungarian Partridge	0	0	0
Ring-necked Pheasant	0	0	0
Turkey	0	0	0
Total Habitat	1,256	5,077	15,918

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 9.-- Acres of Projected Habitat Losses to Coal Development in Big Horn County, Montana, in the Most Probable Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	827	4,839	14,257
Antelope	0	0	0
Sage Grouse	827	4,839	13,913
Sharp-tailed Grouse	827	4,839	14,257
Hungarian Partridge	827	4,839	13,563
Ring-necked Pheasant	0	1,272	3,935
Turkey	201	461	2,524
Total Habitat	827	4,839	14,257

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 10.--Acres of Projected Habitat Losses to Coal Development in Rosebud County, Montana, in the Most Probable Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	2,561	7,713	27,082
Antelope	2,561	7,315	21,866
Sage Grouse	2,561	7,713	26,596
Sharp-tailed Grouse	2,561	7,713	27,082
Hungarian Partridge	2,561	7,713	26,596
Ring-necked Pheasant	1,939	4,669	17,816
Turkey	0	0	920
Total Habitat	2,561	7,713	27,082

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 11.--Acres of Projected Habitat Losses in Coal Development in Oliver & Mercer Counties, N. D., in the Most Probable Forecast [1]

Species	Year 1980	1985	2000 [2]
Deer[3]	1,276	6,563	30,320
Antelope	1,276	6,563	30,320
Sharp-tailed Grouse	1,276	6,563	30,320
Hungarian Partridge	1,276	6,563	30,320
Ring-necked Pheasant	1,276	6,563	30,320
Turkey	458	1,258	4,020
Total Habitat	1,276	6,563	30,320

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 12.--Subjective Evaluation of Significance of Losses shown in Tables 7, 8, 9, 10, and 11 (Most Probable Forecast)

		Deer	Antelope	Other Big Game	Sage Grouse	Sharp-tailed Grouse	Hungarian Partridge	Ring-necked Pheasant	Turkey	Total Habitat
NGPRP Study Area	1980	A	A	A	A	A	A	A	A	A
	1985	A	A	A	A	A	A	A	A	A
	2000	S	A	A	S	A	A	A	S	A
Campbell Co.,Wyo.	1980	A	A	O	A	A	A	O	O	A
	1985	A	A	O	A	A	A	O	O	A
	2000	S	S	O	A	A	A	O	O	A
Big Horn Co., Wyo.	1980	A	A	O	A	A	A	O	A	A
	1985	A	A	O	A	A	A	S	A	A
	2000	S	A	O	S	S	A	S	S	A
Rosebud Co., MT.	1980	A	A	O	A	A	A	A	O	A
	1985	A	A	O	A	A	A	A	O	A
	2000	S	A	O	S	S	A	S	A	A
Oliver and Mercer Counties,N.D.	1980	A	A	O	O	A	A	A	A	A
	1985	A	A	O	O	A	A	A	A	A
	2000	S	S	O	O	A	S	S	A	A

O - Little or no impact.
A - Some adverse impact.
S - Serious losses.
M - Major losses, some of disastrous proportions.

Table 13.--Acres of Projected Habitat Losses to Coal Development In the Study Area in the Extensive Development Forecast 1/

Species	Year 1980	1985	2000 2/
Deer 3/	18,507	67,732	277,255
Antelope	15,007	58,594	210,842
Other Big Game	167	257	2,216
Sage Grouse	6,825	24,716	142,669
Sharp-tailed Grouse	17,675	59,958	213,970
Hungarian Partridge	15,907	54,836	177,795
Ring-necked Pheasant	13,016	43,177	122,638
Turkey	5,809	17,103	83,208
Total Habitat	18,931	71,461	294,538

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 14.--Acres of Projected Habitat Losses to Coal Development in Campbell County, Wyoming, in the Extensive Development Forecast [1]

	Year		
	1980	1985	2000 [2]
Deer[3]	832	6,447	39,921
Antelope	1,256	9,472	47,395
Other Big Game	0	0	39
Sage Grouse	248	728	4,762
Sharp-tailed Grouse	0	0	97
Hungarian Partridge	0	0	0
Ring-necked Pheasant	0	0	0
Turkey	0	0	676
Total Habitat	1,256	9,824	52,597

[1] Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

[2] Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

[3] Includes habitat of both mule deer and white-tailed deer.

Table 15.--Acres of Projected Habitat Losses to Coal Development in Big Horn County, Montana, in the Extensive Development Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	2,099	6,900	43,433
Antelope	0	0	7,465
Sage Grouse	2,099	5,348	27,256
Sharp-tailed Grouse	2,099	6,900	42,519
Hungarian Partridge	2,099	5,348	32,191
Ring-necked Pheasant	0	1,283	8,803
Turkey	201	1,744	9,225
Total Habitat	2,099	6,900	43,436

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 16.--Acres of Projected Habitat Losses to Coal Development in Rosebud County, Montana, in the Extensive Development Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	4,020	14,124	65,416
Antelope	4,020	11,646	42,274
Sage Grouse	4,020	14,124	67,613
Sharp-tailed Grouse	4,020	14,124	65,974
Hungarian Partridge	4,020	14,124	67,951
Ring-necked Pheasant	1,939	5,173	30,411
Turkey	1,459	3,558	17,420
Total Habitat	4,020	14,124	68,217

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

Table 17.--Acres of Projected Habitat Losses to Coal Development in Oliver and Mercer Counties, North Dakota, in the Extensive Development Forecast 1/

Species	Year		
	1980	1985	2000 2/
Deer 3/	5,050	17,407	64,785
Antelope	5,050	17,407	64,785
Sharp-tailed Grouse	5,050	17,407	64,785
Hungarian Partridge	5,050	17,407	64,785
Ring-necked Pheasant	5,050	17,407	64,785
Turkey	2,345	8,567	34,376
Total Habitat	5,050	17,407	64,785

1/ Includes only good and medium quality habitat lost, except Other Big Game and Turkey also include low quality habitat lost.

2/ Acreages stripmined between 1972-1975 are considered restored and have been subtracted from year 2000 totals.

3/ Includes habitat of both mule deer and white-tailed deer.

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Table 18.--Subjective Evaluation of Significance of Losses shown in Tables 13, 14, 15, 16, and 17 (Extensive Development Forecast)

		Deer	Antelope	Other Big Game	Sage Grouse	Sharp-tailed Grouse	Hungarian Partridge	Ring-necked Pheasant	Turkey	Total Habitat
NGPRP Study Area	1980	A	A	A	A	A	A	A	S	A
	1985	A	A	A	S	A	A	A	S	A
	2000	M	S	S	S	A	A	S	M	S
Campbell Co., Wyo.	1980	A	A	O	A	A	A	O	O	A
	1985	A	S	O	A	A	A	O	O	A
	2000	S	M	A	A	A	A	A	S	S
Big Horn County, MT.	1980	A	A	O	A	A	A	O	A	A
	1985	A	A	O	S	A	A	A	A	A
	2000	M	S	O	S	S	A	A	M	S
Rosebud County, MT.	1980	A	A	O	A	A	A	A	A	A
	1985	S	A	O	A	A	A	A	A	A
	2000	M	S	O	S	S	A	M	S	S
Oliver and Mercer Counties, N.D.	1980	A	A	O	O	A	A	A	A	A
	1985	S	S	O	O	A	S	S	S	A
	2000	M	M	O	O	S	M	M	S	S

O - Little or no impact.
A - Some adverse impacts.
S - Serious losses.
M - Major losses, some of disastrous proportions.

Discussion Draft
March 1974

IMPACTS OF COAL AND RELATED DEVELOPMENT ON RECREATION RESOURCES

I. INTRODUCTION

An analysis of the impacts of coal and related development on recreation resources must include consideration of both tangible and intangible values. It also must include consideration of not only the areas where there will be land disturbance as a result of strip mining and the construction of aqueducts, transmission lines, highways, and railroads, but also the impacts of additional people, the effects of development on air and water pollution, costs related to developing and maintaining recreation areas, concern for the attitudes of people, consideration of existing laws and policies, and, finally, concern for the preservation of a relatively unique "way of life" that still remains in this study area. It is recognized that some of these concerns are of a wider scope than an analysis of impacts on surface resources might warrant. However, it is difficult to make a separation and valid analysis of impacts on surface resources without giving them some recognition. Although this analysis relates primarily to the impacts of coal and related development, it must be understood that an adequate analysis would require the consideration of the development of other minerals that might occur in this region and an analysis of how the development of minerals in this region will meet needs in other parts of the nation. Of possibly greater importance is the need to know how the coal resources in this region may or may not be required to meet energy requirements in the context of other sources of fuel, especially domestic oil, geothermal, solar, garbage, etc., and the projected time frames in which they may occur. It is imperative that decisions on an extensive strip mining program should not be made without this knowledge. It is clear that there are numerous alternatives for developments and reclamation that may or may not be initiated. For this reason, it has been necessary for the purpose of this study to develop a series of assumptions upon which the impacts of development can be judged. With this set of assumptions in mind, hopefully, the decisionmakers can then determine what some of the impacts may be with certain courses of development. One final note: data for the study is geared to three target years, 1980, 1985, and 2000. Examination of the proposed developments that are projected to occur in the year 2000 indicates that the year 2000 is the beginning of when the most significant impacts will occur. For this reason, the following text will make mention of impacts beyond the year 2000. It is suggested that other disciplines involved in the study also should consider the 25- to 30-year period beyond the year 2000 in their analysis of impacts.

II. ASSUMPTIONS

In addition to the basic assumptions established for the Surface Resources Work Group, five additional assumptions were made to facilitate analyses of impacts on recreation resources.

1. Assume there will be a geometric impact, not a linear impact, on resource base for wildlife species and the ecosystem they are a part of by development of coal. Other mineral development will magnify this impact.

2. In assessing the impacts of coal and related development on recreation resources, assume that impacts will not be limited to the specific piece of ground being disturbed, but that physical, social, and economic impacts will occur throughout the region or the sample area being analyzed.
3. Assume, for purposes of this study, that in assessing the impact of coal and related development on the recreation resources there will not be a need to determine the degree of demand or need for certain types of recreation.
4. Assume that since locations and relationships of various coal and related developments and kinds of reclamation efforts are not known, the analysis of impacts may not relate to specific recreation resources. The analysis will be conceptual, and will relate to specific recreation resources only as available information permits. For instance, the location and size of new towns and the numbers of new people that may come into the area are not known at this time; neither are the exact locations of services related to coal mining activities.
5. Assume that recreation resources lying outside of the study area will be impacted by people and service facilities related to coal development in the region. For example, Yellowtail Dam is the key source of water for the proposed coal development in the Gillette area. Recognition of impacts on the recreational use of this reservoir must be made.

III. ANALYSES--RESULTS AND DISCUSSION

Campbell County, Wyoming

There are more than three million acres of land in Campbell County. Of this amount, slightly more than 381,000 acres of land and only 445 acres of water have been inventoried as available for recreation activities. However, the Wyoming State Comprehensive Outdoor Recreation Plan (SCORP) indicates that almost 1,132,000 acres of private land is used for privately operated outdoor recreation enterprises. These consist, largely, of 132 hunting enterprises. The following broad statement in the SCORP definitely would apply to the resources that are available in Campbell County. The statement says: "A consideration of Wyoming's supply of recreational resources is, in essence, a consideration of the state itself. With the possible exception of residential and industrial areas, recreational opportunities exist throughout the state. Even residential and industrial sites hold aesthetic appeal for many sightseers. Wildlife, either big game animals or upland game birds, can be found in virtually every non-urban area of Wyoming. All streams, lakes and other water impoundments in the state support game fish and waterfowl. When these recreational opportunities are combined with Wyoming's varied topography, it is difficult to find an area of the state that does not have recreation potential. Campers, hikers, mountain climbers, skiers, water sport enthusiasts, and other recreationists have a myriad of recreational area choices."

In recent years, snowmobiling has become an important activity, especially in the Big Horn Mountains and other high country areas. In these areas the U.S. Forest Service has designated trails and provides maps for snowmobilers; however, the Wyoming Recreation Commission administers this activity throughout the state. A statewide study of the impact of snowmobiling as a recreation activity, partially funded by the Bureau of Outdoor Recreation, currently is underway.

"Perhaps, as important as the recreational potential topographically , is the availability of these resources to the public. The 'multiple use' concept, created by Federal legislative enactment in June 1960, states that, '...it is the policy of the Congress that the National Forests are established and shall be administered for outdoor recreation, range, timber, watershed and wildlife and fish purposes.' (U.S. Department of Agriculture, Forest Service, Multiple Use, Mandate for Management) Lands administered by the Bureau of Land Management were included under the multiple use provision by the Classification and Multiple Use Act of 1964. (U.S. Department of the Interior, Bureau of Land Management, Public Lands in the Western United States, Washington, D.C., October 1964). The policy of multiple use is essentially the public's guarantee of accessibility to existing recreation opportunities on public lands."

In addition to existing recreation resources, three areas were listed as potentially suitable for designation as a recreation resource. Two of these have potential for designation as national landmarks--Pumpkin Butte in the southwest part of the county and Rozet Escarpment east of Gillette. The third potential area is the scenic highway, State 59, extending 100 miles southward from Gillette.

Although rurally oriented, Campbell County contains 9 municipal parks and playgrounds, totalling 108 acres. These include one 9-hole golf course and one outdoor swimming pool.

As a basis for better understanding the impacts of coal and related development in Campbell County, the following quotations are included from the State Comprehensive Outdoor Recreation Plan concerning the determination of needs. "Preferably, determination of needs would begin with participation patterns of each activity that accurately reflect areas and facility requirements. These requirements could be applied to projected participation estimates to establish total area and facility needs for each activity. From these estimates, the supply of existing facilities could be subtracted to derive net acreage or facilities needed. In anticipation of this task, the Wyoming Recreation Commission intiated research projects with the University of Wyoming to develop participation patterns and area and facility preferences of both resident and out-of-state participants for boating, winter sports, camping and picnicking activities. In more general terms, the 1967 resident and out-of-state surveys also provided information that could be used to establish area and facility requirements (Dwight M. Blood, Clynn Phillips, Outdoor Recreation in Wyoming, Volume I, Participation in Outdoor Recreation by Wyoming Residents /Laramie, Wyoming: Division of Business and Economic Research, College of Commerce and Industry, University of Wyoming, March 1969/). The results of these studies were utilized in translating the participation projections into facility needs.

The Wyoming Game and Fish Commission has accumulated considerable data pertaining to hunting and fishing participation patterns through its continuous research program. Also, the Wyoming Game and Fish Commission has initiated a study with the University of Wyoming to determine participation patterns, socio-economic characteristics, and expenditure patterns of Wyoming hunters and fishermen.

"Of the 13 outdoor recreation activities included in the Wyoming demand analysis, four activities--attending athletic events, hiking, attending rodeos, and sightseeing and pleasure driving--were not included in the needs determination. Two of these activities (sightseeing-pleasure driving and hiking) do not require special facilities for participation, and the area available for participation includes nearly the entire state. Although sightseeing is an important recreation activity, not only is it difficult to define and quantify, but it is almost impossible to describe the facilities required for participation. Wide dissemination of the list of historical and archeologic sites and landmarks now being prepared as part of the state historic preservation plan would provide recreationists with a greater range of sightseeing opportunities. The Recreation Commission's effort to film some of the states' interesting but less publicized historical attractions will undoubtedly create an interest in many of these areas that will result in more sightseeing visits."

The Continental Divide Trail has been studied by the Bureau of Outdoor Recreation for recommendation to Congress, and the Mormon and Oregon Trails are currently under investigation.

Municipal Park Standards

The Wyoming Recreation Commission utilizes a Recreation Action Team (ReACT), composed of federal-state leaders, to facilitate the coordination of recreation planning and development activities by federal and state land-managing agencies. This activity is partially assisted by a Bureau of Outdoor Recreation planning grant.

Also, the Governor of Wyoming has recently appointed a special team of key state personnel. This task force is now operating at the request of the Governor to do on-going finite planning to control all development in Campbell County. The first meeting of this task force was on February 25, 1974.

Base Forecast

Physical Resource Impacts

Data for the Base Forecast, Campbell County, indicate the following estimates of sections of land that may be disturbed by coal stripping and related development:

1980	1985	2000
2	6	20

Projected for the year 2000 is one new export mine and one power generation plant. Reference to the Land Ownership map shows that the distribution of recreation Class II and III land (mostly National Resource Land and National Grassland) occurs in checkerboard and segmented blocks throughout the county, with the strippable coal region crossing a mixture of federally and privately owned Class III land. There may be little or no adverse impact on the availability and quantity of this type of recreation resource in 1980, except for those acres actually disturbed by mining and related development. To the contrary, new roads built for mining may even provide access to lands not now readily accessible to recreationists. Also, the occurrence of mining will provide a new attraction for sightseers, a form of recreation. Both benefits, increased access and sightseeing attractions, would continue through the year 2000. Also, with the building of a powerplant in the year 2000, there may be an opportunity to use the powerline right-of-way for development of a trail. On the negative side, beginning in about 1985, with over six sections of land altered from mining, there will begin to be a noticeable change in the present character of the area, a feature that now makes it relatively unique to both recreationists and residents. This change will continue to grow to the year 2000, when--with over 20 sections of land altered--it will be of serious concern to those desiring the recreation opportunities provided by Class III type land. By the year 2000, there will be not only a visual deterioration of the general area, but also, with construction of the powerplant, some deterioration of air quality. Even with air quality standards being met, with present technology, there remains the possibility that both visual and nonvisual pollutants may escape; and have either an immediate or a long-range effect on the flora and fauna portions of the recreation resource base. For example, long-range studies are needed to understand the effects of minerals released by burning coal on both flora and fauna that are an important part of the recreation resource base in this country.

Surface water does not play a major role in the recreation opportunities now available in Campbell County. It seems reasonable to assume, however, that Edwards Reservoir and Dalby Lake will receive more use as more people move into the area. As a result, more recreation facilities may need to be provided at these areas. The Belle Fourche River, although small, contains trout and is an important recreation resource at least locally. More significantly, it feeds the Keyhole Reservoir, a State Recreation Area, immediately downstream. Since the major coal strippable area lies across the headwaters of this stream, it is essential that every effort be made not to deteriorate the quality of this stream.

The physical impact that may occur on the potential recreation resources in Campbell County is even more difficult to analyze. State Highway 59, a scenic route, extends about 100 miles southward from Gillette, but for the most part lies west of the strippable coal area. The Rozet Escarpment, a potential National Landmark, lies east of Gillette, just beyond the strippable area. Pumpkin Butte, another potential National Landmark, is located further from the strippable area in the southwest corner of the country. Impacts that may affect these areas will be related to coal development. These will occur in the form of greater recreational use or possibly in the form of visual impacts caused by nearby alignments of roads, railroads, aqueducts, or transmission lines. For example, a new railroad and spur lines are being proposed to extend southward from the Gillette area. The Bureau of Land Management currently is preparing an Environmental Impact Statement on the project. Another adverse impact will result from the creation of new towns, unless their location, size, and service facilities are carefully planned. Since locations of these potential impactors are not now known, decisionmakers should make every effort when approving development plans to ensure that unique and high quality recreation resources are not impaired.

In association with at least one new town and the other developments planned in Campbell County, a reservoir is being considered for the Hole-in-the-Wall area.

Use Characteristics

An analysis of impacts caused by increased recreational use of surface resources is even more difficult than is the analysis of impacts caused by mining-related surface disturbance. Traditionally, Campbell County was agriculturally oriented until the late 1960's when there were large petroleum discoveries. More recently, the expansion of coal mining activities has made the county increasingly oriented toward mineral development. This oil-coal "boom" is still occurring in the county, along with extensive uranium leasing in the Pumpkin Butte area.

Gillette, the county seat, is the only town in the country with a population of over 1,000. In 1970, it had a population of 7,194, more than double the 1960 figure. Past trends are of very limited use in trying to analyze the impacts that will be generated by the large number of people projected to move into this area. The Wyoming Recreation Commission has initiated a study of Campbell County to analyze the recreation needs of an impacted area. The county had a population of 12,957 in 1970. Projected increases for the Base Forecast are:

1980	1985	2000
17,500	18,000	21,100

Certainly, by almost doubling the population of the county by the year 2000, the use of recreation resources will at least double. In fact, the recreation use rate may be even greater than now, since most of the new people coming into the area will not be involved in agricultural pursuits, and therefore will seek recreation activities to a higher degree than those who live in the area now. Beginning in about 1980, there will be a continuing increase in conflicts with other interests in the utilization of recreation resources. Many people associated with the initial influx will be associated with the construction phases of development and will be transitory in nature. For this reason, there will be a tendency to have less respect for the resource base and, consequently, the management of recreation resources will become more of a problem. As such problems become more severe, there will be an increasing tendency of landowners to prevent trespass on their property.

Legal Aspects

Most of the land that is now in a Class III category is under the administration of the Bureau of Land Management and the U.S. Forest Service. These lands are managed under a multiple use concept. With about 20 sections of land projected to be disturbed by coal mining and related developments by the year 2000, the impact may be significant enough that these agencies will have to analyze their policies concerning multiple use management. On a more local level, and especially as it concerns privately owned lands, there will be a need for establishment of zoning or other controls to manage the new towns and the services that the influx of people into the area will require. Also, as more people move into the area, the enforcement of existing laws and the management of these people on the recreation resource base will become more costly and difficult.

Economic Aspects

A population increase in the county will afford economic opportunities to those establishments that provide services to the recreationists. However, governmental agencies at the federal, state, and local levels that provide recreation facilities will encounter an ever-increasing economic burden in furnishing the kinds of facilities that newcomers to the area will require. These facilities will tend to be more costly than the kinds of facilities now found in the county. Again, since many of the newcomers will be transitory and the increase in population is apt to occur over a period of a very few years, an adequate tax base for funding recreation facilities will not have been developed. For this reason, it may be appropriate to begin planning to ameliorate the burden of providing and maintaining recreation facilities for those persons likely to be attracted to the area.

Attitudinal Aspects

Already there is occurring in this region a tendency of local landowners to prevent trespass on their property for recreational pursuits. This tendency will become more common and is likely to result in rivalry between long-time residents and newcomers associated with the coal industry.

Historic and Scientific Aspects

Historically, this area is known for its ranching activity and its relatively unspoiled wide open spaces. For recreationists, this has been the major attraction of the area. It is difficult to forecast when this character will begin to change with the disturbance of land associated with coal mining.

The six sections of land that are predicted to be mined or disturbed by 1985 may or may not be greatly noticeable and may or may not detract from the natural and historic character of the area. However, by the year 2000, with about 20 sections projected to be disturbed, it would seem that the general historic and natural character of the area would tend to deteriorate. Although mining of the magnitude predicted will most likely tend to draw a considerable number of tourists through the area, there may be a decrease in the number of those who are seeking recreation associated with natural type areas.

Although no archaeological sites have been inventoried in the county, it is possible that some may be discovered during the mining operation. For certain sites of historic interest (such as petroglyphs) not already well known to the public, it may be necessary to withhold information about their location until facilities or structures can be provided to protect the site from vandalism or other damage.

Most Probable Forecast

Physical Resource Impact

The number of sections of land projected to be disturbed under this forecast level is estimated to be:

1980	1985	2000
2½	10	33

In addition to the existing mines, there is projected to be one new export mine started in 1980. This degree of activity most likely will not have a significant impact on the recreation resources of the county. Beginning in 1985, however, there will be one more export mine, plus one gasification plant. This will require the construction of more new roads and the construction of an aqueduct. Most likely these activities will open up new areas for recreational uses. Possibly, the aqueduct right-of-way can be considered as usable for a trail for recreational use. However, with the disturbance of about 10 sections of land, there will begin to be a detrimental visual effect and about a two percent decrease in the amount of existing Class III land now available in the county for recreational use. By the year 2000 there is projected to be an additional export mine and the development of one power generation plant. Again, developments associated with these plants likely will open more lands for recreational uses. Transmission lines associated with the power plant may be potential locations for trail development. However, these benefits may be overshadowed by the projection of about 33 sections of land being disturbed. This amounts to about 6 percent of the Class III land now available in the county for recreational use. Most certainly this disturbance of land, plus the associated developments relating to the services required by the population influx will cause a considerable visual impact on the historically rural character of the area. It will mean a significant decrease in the amount of Class III recreation land available and it is possible that there will be a significant deterioration of both flora and fauna.

Use Characteristics

Under this Most Probable level of development the 12,957 population in 1970 is projected to increase as follows:

1980	1985	2000
21,100	27,900	29,000

The characteristics of recreation activities associated with this population influx will be similar to those described for the base forecast. The only difference is that the problems will be magnified by the increased numbers of people. The recreation resources will receive more use pressure and, being fragile, tend to deteriorate more rapidly. Also, the value of the recreation experience will, for many, be diminished. There will be more conflicts with other interests in the use of the resource base and quite likely there will be a greater incidence of vandalism through greater disrespect for the resource base that exists there now. This will result in a greater incidence of lands posted against trespass.

Legal and Economic Aspects

Impacts will be similar to those described for the base forecast. There will be a greater need for zoning laws to control the developments associated with servicing the influx of people into the area. Problems associated with enforcement of existing laws will be more difficult and possibly some existing laws and agency policies will need to be revised to accommodate the level of development projected for this area. The 33 sections of land projected to be disturbed by the year 2000 will mean a significant loss of land now available for recreational pursuits. Costs of reclaiming this land, whether for recreation or agricultural activities, will be considerable and most likely the costs associated with maintaining it in its reclaimed condition will be considerably more than costs associated with managing it as it now exists. Although private establishments providing services to the recreation industry will tend to benefit by a greater number of people in the area, the cost to the various levels of government in providing facilities for public use will be considerably greater. As mentioned under the base forecast, it would seem appropriate that since many of the newcomers into the area will be transient in nature and since a tax base most likely will not be adequate to fund the development, operation, and maintenance of the more costly kinds of facilities that these people will require, careful planning should be begun now to find sources of funding.

Historic and Scientific Aspects

Conditions will be similar to those described under the base forecast, only magnified. However, by the year 2000 the magnitude of disturbance will be considerably greater and the historic and natural character of the area will be considerably diminished.

Extensive Forecast

Physical Resources Impacts

Under the extensive level of development we estimate the following number of sections of land to be disturbed by coal mining and related developments:

1980	1985	2000
2½	20	83

As with the other forecast levels, the impacts are not expected to be significant by 1980. However, by 1985 in addition to the 20 sections of land that are projected to be disturbed by mining and related developments, three new export mines and four gasification plants are proposed. A series of aqueducts will be associated with the gasification plants and may provide some opportunity for trail development along the aqueduct right-of-way. However, mining, construction of gasification plants, aqueducts and associated facilities of this magnitude will begin to make a significant change in the natural character of the recreation resources that now exist in the county. By the year 2000, there are projected to be an additional 14 export mines, one more gasification plant and one power plant constructed. These are in addition to the 83 sections of land that will be disturbed by mining and related developments. This constitutes about 14 percent of the Class III recreation resource base in the county. Disturbances of this magnitude will severely alter the character of the resources that are now available for recreation. The vastness of the recreation resource lands will be considerably decreased. There is the possibility that the quality of both air and water will be affected and that the flora and fauna that constitute part of the recreation resource will significantly and possibly irreversibly deteriorate. In addition, the visual change caused by this magnitude of development will be severe. There is a very real possibility that the two unique resources in the county, the Rozet Escarpment, especially, and to possibly a lesser extent the Pumpkin Butte potential National Landmark will be impacted. These impacts may occur as a result of stripping for coal or the construction of aqueducts, roads or transmission lines, or from the influx of people into the area associated with the mining activity. Also, with the magnitude of development projected for the year 2000, special care will have to be taken to protect the Belle Fourche River, not only within the county, but also, extend out of the county to the quantity and quality of water that flows to the Keystone Reservoir and State Recreation Area immediately downstream.

Use Characteristics

Under this level of development, the 1970 population base of 12,950 people, is projected to increase as follows:

1980	1985	2000
25,700	40,500	73,300

The year 2000 forecast is a nearly six-fold increase over the 1970 population. Quite likely, a large majority of the people coming into the area will be located in small- to-medium sized urban centers. Therefore, they not only will be seeking an urban-type recreation, but also will cause a very significant impact on surrounding rural recreation resources. If the municipal park standards used in the State Comprehensive Outdoor Recreation Plan are applied to this population increase, there will be a need for at least 760 acres of municipal park land and possibly, as much as 1,500 acres, depending on the size of the communities that are created by the people associated with the coal development. As mentioned under the other two forecast levels, there will be special problems associated with meeting the recreation needs of these people since a considerable proportion of them, especially those initially coming into the area will be of a transient nature and most likely will not be contributing significantly to the tax base required to provide the recreation facilities that they will be using. The impacts on rural recreation lands in the county will be very significant and management will become a special problem in order to protect the relatively fragile resource base. Control of off-road vehicles will be a special problem as will problems associated with trespassing on private lands.

Legal Aspects and Economic Aspects

Impacts associated with these concerns have been fully discussed under both the base and most probable forecast level discussions and will apply to this forecast. One major economic loss which would be far greater under this development scenario is the anticipated loss of much of the income currently brought into the area by non-resident deer and antelope hunters. Currently, non-residents outnumber resident hunters for these species in this part of Wyoming and contribute a significant source of outside income to the area. Most of this comes from guide and trespass fees, tourist services, and higher license fees. Increased hunting demand by new residents would preclude availability of most non-resident permits.

Historic and Scientific Aspects

These also have been discussed under the other two forecast levels. However, the degree of change as it related to the historic and scientific aspects of the recreation resource base between the target years 1985 and 2000 is of such magnitude that there will be a complete change of character of the area by the year 2000. With the proliferation of export mines, gasification plants and the power plant and the associated development, there will remain little semblance of the rural, agricultural character remaining of the area that now exists.

Mercer and Oliver Counties

These two counties occupy an area of nearly 1,177,000 acres of land and water. The existing acreage of recreation land and water is only 5,801 acres. This figure may be somewhat misleading, however, since the extensive adjoining water acreage of the Missouri River and Lake Sakakawea are not included. Only 484 acres of other water, mostly in small farm ponds, were included in the tabulation of existing recreation area resources. There were two potential resource areas included in this sample area; one consists of Indian Reservation land occupying slightly more than 27,000 acres of land, which is potential Class III acreage; the other area is the Knife River Indian Villages National Historic Site which would occupy another 1,067 acres and would be a Class VI area. A major reason for the relatively small amount of recreation land in this sample area is that less than five percent of the two counties is under Federal administration. For example, there are only 733 acres of Natural Resource Lands and no U. S. National Forests or Grasslands. This contrasts sharply with the more than 380,000 acres of such land in Campbell County, Wyoming.

Before analyzing the impacts that might occur under each of the forecast levels of development, it may be well to include some excerpts from the North Dakota State Comprehensive Outdoor Recreation Plan. Mercer and Oliver Counties fall within planning region 7. The two counties are primarily rural and the following paragraph relating to standards would apply to the situation that exists in this sample area. "It can easily be seen how the needs of many communities in North Dakota are overlooked on a regional planning basis when one realizes that the mean population of North Dakota cities is approximately 300. The needs for these smaller rural communities are as real and as pressing as the needs for the large urban city. The people living in the rural communities deserve softball or golf or swimming facilities and all the other types of facilities just as much as the businessman and his family living in a city of 100,000. It is imperative that these needs be recognized and provided for.

"All the people of North Dakota, whether they live in the small rural town or in the large urban city, deserve quality recreation opportunities on an equal basis. The urban cities' needs are great, for they must provide recreation for a large number of people. But, the needs of rural North Dakota are just as great. Rural North Dakota may be the most recreationally deprived group in the state. It is time special efforts be made to upgrade the quality of rural life in North Dakota and give it far greater attention and priority. Rural North Dakota has been ignored in the past. The same mistake cannot be made in the future."

Since the 1970 population of 8,497 is projected to increase to anywhere between 13,000 and nearly 62,000 people by the year 2000 depending on the forecast and since it is likely that most of these newcomers will live in cities, it may be well to quote the standards adopted for city park and recreation areas for North Dakota.

"It is very important that enough park and recreation areas be provided to meet the needs of the people of a city. Naturally, the more people in a city, the more park and recreation lands necessary. Approximately 10 percent of a city's area should be devoted to recreation and open space lands. The following guidelines are recommended as minimum standards according to the population of a city.

Population	Acres of Park and Recreation Lands
8,000 and up	1 acre per 100 population
5,000 to 8,000	1 acre per 75 population
2,500 to 5,000	1 acre per 60 population
1,000 to 2,500	1 acre per 50 population
under 1,000	1 acre per 40 population

In region 7, by far the most popular recreation activity is picnicking. Sixty-eight percent of the people in this region participate in this activity. It is followed by fishing with 52 percent, boating - 30 percent, swimming in swimming pools - 33 percent, other swimming - 28 percent, camping - 35 percent, walking, hiking, and nature study - 27 percent, and bicycling - 27 percent.

Some of the recommendations in the North Dakota SCORP are:

"Public and private developments of outdoor recreation areas and facilities should be complementary to each other."

"Access to water-based recreation opportunities should be assured through acquisition of access areas, easements along private shorelines, zoning of water areas, consideration of water access in highway design, and other feasible means."

"Proper zoning of areas should be followed for maximum recreation benefits, to maintain high quality standards and to protect the public welfare when conflicts of interests are present."

"Recreation areas should be defended against encroachments from nonconforming uses, both public and private. If recreation land must be taken for other public use, it should be replaced with land of similar quality and comparable location. The limited forest resources in the state should be properly managed and preserved."

"Operation and maintenance costs of multipurpose recreation reservoirs and other developments which draw people from several counties should be shared by the involved counties on a benefit-use ratio."

"Private development of camping, picnicking, and other recreational areas should be encouraged wherever the opportunities exist."

Needs, which are deficiencies of outdoor recreation areas and facilities, as they were determined in the State Comprehensive Outdoor Recreation Plan, probably do not take into consideration the magnitude of population increase that is projected for the most probable or extensive levels of development.

Base Forecast

Physical Resource Impacts

Projected information on the base forecast level of development for Mercer and Oliver Counties indicates the following number of sections of land will be disturbed by coal mining and related developments:

1980	1985	2000
6	11	29

As previously mentioned, there are only about 5,800 acres of existing recreation land in this area and about another 28,000 acres of potential recreation resource land, of which the majority is Indian Reservation. Most of the Indian Reservation land lies outside of the area that is projected to be strip mined and as a result, probably will not receive much in the way of direct impact in the way of actual land disturbance. The most significant impacts to the existing and potential recreation resource base are most likely to occur along the stream valleys. This is especially true along the Knife River. Although it is difficult to tell now which of the existing Class II and III lands will be disturbed, it is quite likely there will be at least a visual change to the area and a change to the flora and fauna, especially that in the river valleys. In that case there would be a significant loss of the already small amount of Class III recreation resource in the county. Other areas that may be impacted at least visually by the year 2000 are the Big Hidatsa National Historic Landmark, the Crowley Flint Quarry and the historic Fort Clark. Special efforts should be made to protect these areas from direct or indirect deterioration.

Use Characteristics

Available data indicate that the 1970 population of 8,497 will increase as follows:

1980	1985	2000
11,490	11,490	13,033

It is likely that most of the newcomers to the area will live in existing towns or that there will begin to be created new towns in the area. In any event, it is likely that these people will seek a combination of urban type recreation and the nearby water resources of the Missouri River and Lake Sakakawea will receive more use. Many of these newcomers also will have an interest in the historical and archaeological sites in the area. For example, the Lewis and Clark Trail and the North Country Trails that border these counties, and which are now under study for possible designation as National Trails, will receive more interest and use and will require more facilities to accommodate this increased interest and use. Most certainly, the Class II and III lands scattered throughout the two counties will receive more use and there will be an increasing demand for recreational activity on privately owned lands.

Legal Aspects

More people and more development will result in a greater need for designation and protection of the trails and remaining prime recreation resources, especially historical and archaeological areas. Zoning laws may become necessary to control the development that takes place on privately owned lands.

Economic Aspects

The increase in use of trails, archaeological and historic sites and the adjacent waters of the Missouri and Lake Sakakawea will require a considerable increase in facilities. The costs associated with providing these facilities will be a burden on the low tax base that now exists in these two counties. Sources of funding for development and for operation and maintenance of the needed recreation facilities should be sought now.

Historic and Scientific Aspects

The most significant impact will be the increased interest by newcomers in historic and archaelogic areas and the need to insure that these kinds of areas are adequately managed to protect them from overuse and from acts of vandalism.

Most Probable Forecast

Physical Resource Impacts

Impacts that will occur under this forecast level will be similar to those described under the base forecast. However, by the year 1985 there should be serious concern over the loss of Class II and III type lands. For example, the following number of sections of land may be disturbed by coal mining and related developments:

1980	1985	2000
6	14	53

Although the exact relationship of the coal mining that will occur and the location of the Class II and III lands that have been inventoried is not known, it is clear that with this magnitude of development every effort should be made to protect the Class II and III lands, especially those of highest quality. Mostly, these occur along drainageways and near the Missouri River and the shoreline of Lake Sakakawea. Likewise, the Class VI areas, especially the Crowley Flint Quarry and the historic Fort Clark and the Big Hidatsa Village National Historic Landmark should be protected from encroachment; both from the mining itself and from the roads, highways, aqueducts or powerlines that may be required to service the coal mining activities.

Use Characteristics

Under this forecast level the 1970 population of 8,497 is projected to increase as follows:

1980	1985	2000
11,490	17,708	29,583

In 1985 there is projected to be one gasification plant built and in the year 2000 there will be one more gasification plant and two power plants. The population that will be associated with the mine activity and the construction of new plant facilities will result in a considerable adverse impact on the recreation resources of the area. In effect, the impacts will be a magnification of those described under the base forecast. Presently, the area is a rurally oriented community. However, with the projected three-fold increase in population, it likely would become urban-oriented with more of a requirement for urban-type recreation facilities. However, with an urban orientation, there would be somewhat more than a three-fold increase in the demand for rurally oriented recreation activities. With the relatively small amount of land under Federal and State administration it is safe to assume that conflicts will occur as a result of the desire for people associated with the coal mining activity to recreate on the privately owned lands that dominate this sample area.

Legal Aspects

Impacts will be similar to those described under the base forecast.

Economic Aspects

Are similar to those described under the base forecast. However, there will be even more of a burden in funding the development and operation and maintenance of facilities required by the more than three-fold increase in recreation activities sought by the people associated with the coal mining activity.

Historic and Scientific Aspects

Impact concerns will be similar to those described under the base forecase level. However, by the year 2000 there is apt to be a major loss in the character of the area as it is now and historic and archaeological sites in the area are likely to be seriously endangered.

Extensive Forecast

Physical Resource Impacts

Under this level of development, there is projected to be the following sections of land disturbed:

1980	1985	2000
12	32	108

Again, the impacts will be a magnification of those discussed under the base forecast level. However, beginning by the year 1985 the visual changes to the area and the disturbances to the recreation resources along valley bottoms and to the natural flora and fauna of the area are apt to be seriously impacted unless very careful planning and control of development occurs. The already small base of Class III land in the area by 1985, and definitely by the year 2000, would be seriously endangered.

Use Characteristics

It is projected that the 1970 population of 8,497 will increase as follows:

1980	1985	2000
23,922	36,354	61,873

The kinds of impacts caused by this level of increase will be similar to those described under the base forecast; however, they can be magnified by at least seven times. Also, there will be an inverse action since some of the Class III lands most certainly will be lost to coal mining or related activities, while at the same time the population and demands for these types of resources will be increasing. Since most of the new people coming into the area would be small-town or urban-oriented, it is safe to assume that there will be a considerable demand for water-oriented recreation activities. Therefore, every effort should be made to provide access to the Missouri River and to Lake Sakakawea. However, these water bodies will not provide all of the water-oriented recreation activities sought by these people. There will be a considerable demand for the activities more normally associated with small lakes and reservoirs.

Legal Aspects

Impacts will be similar to those previously described under the other forecast levels.

Economic Aspects

Impacts will be similar to those previously described, except, again, the cost will be magnified in similar proportion to the level of development and population increase.

Historic and Scientific Aspects

Impacts will be similar to those previously described except that by the year 1985 and certainly by the year 2000 there is likely to be a major loss of the historic and some of the archaeologic resources of the area. This will occur, if not from direct coal mining activities, at least by a change in the general character of the area.

Big Horn County, Montana

Big Horn County contains nearly 3.3 million acres of land and water. There are just over 99,000 acres of land and 12,288 acres of water that make up the existing recreation resource base. However, there is an additional more than 1.5 million acres that is largely tribal land which can be considered as potentially suitable recreation resource acreage. There is a wide variety in the kinds of recreation resources located in the county. They range from Crow Reservation Indian land to the Big Horn Canyon National Recreation Area and include the Yellowtail Dam and Reservoir and the historically important Custer Battlefield National Monument. In addition, there is a large acreage of Natural Resource Lands and private lands that provide an extensive acreage for general types of recreation activity. The county also contains numerous potential recreation resources in the form of historic sites, natural landmarks and archaeological sites.

The Montana State Comprehensive Outdoor Recreation Plan provides considerable insight into the present recreation climate of the state and provides a basis for a better understanding of how residents of the state may react to impacts caused by coal mining and related developments. In the foreword of the Plan it states "Montana families have long had more than passing interest in the out-of-doors, and in the many recreational activities and pursuits associated with the outdoor environment. For many, the interest has developed into a deep concern. They are concerned with the future of the resource that has been the basis of so much enjoyable activity in the past. There is an awareness of mounting pressures upon this resource, both from the recreationists themselves, and from the nature of the economy which seems insatiable in its demands."

The foreword of the plan further states that "the planning process, in order to be viable and realistic, cannot remain solely in the hands of the agency or the government. The Montana citizen is needed in the process. "

"Dispersed recreational use has for decades, of course, been the characteristic pattern of the hunter and the fisherman and the lone backpacker. Today, however, the hunters and fishermen have been joined by literally thousands of fellow outdoorsmen, including families, and the entire outdoors has become the family playground. Montana's 28,000,000 acres of public lands beckon as never before, and the public has responded accordingly."

"Now, more than ever, the mobility of the user will require very strategically located key developments in order to assure optimum use, or to assure their being used at all. A mobile and self-sufficient outdoorsman is a discriminating user, and facilities not to his liking will be bypassed in favor of more attractive areas in the next county or in the next forest. The nature of development will change, for little development is actually needed in many instances. Key sanitary stations are among the critical elements in planning for this dispersed activity."

The ways in which the state intends to provide opportunities for its residents are described in the "Goals" section of the Montana SCORP.

"It is the goal of the state of Montana to provide for appropriate recreational use of its natural resources, consistent with the capability of the resource to supply such use, and with the obligation to preserve these resources for the benefit and enjoyment of future generations."

The Montana SCORP includes a recently completed special section on "Standards and Guidelines for Urban and Non-Urban Recreation Resources and Facilities." These are preliminary, and are to be field tested during calendar year 1974. Nevertheless, they contain valuable information for the decisionmakers, public and private, concerned with the impacts of coal development and providing for the various needs and services of the related population.

The reader can reach a couple of important conclusions from the Montana SCORP. The plan primarily explains the recreation characteristics of Montana residents. The recreation opportunities they desire are of an extensive, rather than an intensive nature, and are coupled with a deep appreciation and understanding of the still relatively unspoiled nature of the wide variety of recreation resources in the state. These conclusions are possible because the state has a low population density with the relatively minor impact it has on the recreation resources.

An exception is the concentration that occurs at the more popular National Parks. All of the foregoing provides a basis to better understand the following analysis of impacts on the recreation resource base as a result of coal strip mining and related developments and the impacts of a large number of new people moving into the area, with highly variable tenure and reasons that are mostly economic.

Big Horn County

Base Forecast

Physical Resource

There is projected to be the following number of sections of land disturbed under this forecast:

1980	1985	2000
1	4	15

This will include one new export mine and two power plants in the year 2000. The major existing recreation resources in the county consist of over 27,200 acres of Natural Resource Lands, nearly 68,500 acres of Crow Indian Reservation land, the almost 9,000-acre Bighorn Canyon National Recreation Area, the nearly 800-acre Custer Battlefield National Monument, and the more than 5,500-acre Tongue River Reservoir. In addition, there are several important state-owned fishing access sites. By far the largest acreage has been classified as a potential recreation resource because it is not generally available for recreation use by the general public. This is the nearly 1,525,000 acres of Crow Indian Reservation land. Also, there is the 640-acre Rosebud Battlefield, a National Historic Site, and several outstanding natural areas. Although included in the list of designated existing and potential recreation resources, no less important is Bighorn River, one of the state's best fisheries, and, to a lesser extent, Tongue River.

The major coal developments are projected to occur in the southeast part of the county. Therefore, the most likely impacts from physical disturbances will occur on Natural Resource Land and near the Tongue Reservoir and River. Both the reservoir and the river are important recreation resources since the recreation opportunities they provide generally are not available elsewhere in the near vicinity. Special care should be taken to maintain recreational use of the reservoir and to maintain the present character of the river and its valley. When the two power plants are built in the year 2000, special care should be taken when locating the plants and related roads and powerlines to not destroy or infringe upon the higher quality recreation resources of the county.

Use Characteristics

The 1970 population of 10,057 is projected to increase as follows:

1980	1985	2000

Projecting the number of people who will live in the county, however, is mostly subjective since it is likely that many coal development personnel will choose to live in or near Sheridan, Wyoming. Furthermore, there also will be an influx of people associated with the export mining that will occur in the Decker and Sheridan areas of Wyoming. The recreation use impacts on recreation areas in Bighorn County then, will result from a population growth in this general area. There is most certain to be an increase in use of the higher quality reservoirs and rivers. Most notably Yellowtail and Tongue Reservoirs, the Bighorn River and the Tongue River. More access points and facilities will be needed to accommodate this increased use. The Tribal lands will be increasingly sought by recreationists. If the Indians decide to permit recreational use of their lands they may be able to receive substantial economic benefits from such use. Since many of the newcomers will be foreign to this area, the Indians should be able to capitalize on providing recreation ranging from guided hunting and fishing trips to the development of more sophisticated recreation facilities, such as interpretive centers or vacation cabins, etc. As the population increases, however, there most certainly will be increased incidents of trespassing on Tribal and other private lands. Care will be needed to keep such incidents to a minimum, since the more often they occur the more likely these lands will be closed to recreational use by the general public.

Use of off-road vehicles for backcountry touring already is one of the most common recreation activities in this area. As pressures from more of this kind of use develop, there will likely be a need for more controls to protect the resource base as well as the safety of the recreationists. Of course, the need for more controls is likely to cause conflicts between long-time residents and the newer coal-related personnel.

Legal Aspects

The interpretation and application of existing Federal and State legislation will become more and more difficult, but necessary, as the magnitude of coal development increases. Especially important will be those laws relating to environmental quality, to water rights, and to the various Federal grant programs. Locally, there will be need for zoning laws to control the new developments. Hopefully, good land use planning laws will be enacted and implemented in time to provide decisionmakers with the necessary information that will show the effects of coal and related development in the overall context in which such decisions should be made.

Law enforcement problems relating to recreation activities will increase. These problems will most commonly relate to trespassing and acts of vandalism. The importance of such incidents could be more significant than normally would be the case if they occur on Tribal lands and generate friction with the Indians.

Economic Aspects

An increase in the use of recreation resources likely will result in economic benefits to those businesses in the private sector that provide support services. As previously mentioned, the Indians could take advantage of this situation if they desire. However, there could be similar opportunities for ranches in the county. Establishments selling recreation equipment and services also should benefit. Conversely, with more use, there will be a need for more public facilities and for more costly operation and maintenance of these facilities. This will place a significant burden on the small communities in the county, especially with the low tax base that now exists. Most such financial burdens will have been generated by those associated with coal development, many of which will be transient in nature. It seems only reasonable that those desiring or profiting from the coal, should pay a fair share of the costs associated with providing recreation opportunities, both for the initial cost and for operation and maintenance. State and Federal agencies also will experience higher costs associated with managing the recreation resources under their control. In some cases, such costs may warrant the initiation of user fees at areas that previously were free.

Historic and Scientific Impacts

These impacts are difficult to assess. Certainly as the magnitude of coal mining increases and as more gasification and power plants with their associated roads, railroads, powerlines and aqueducts are built there will be a gradual change in the historic character of the general area. Designated historic areas will receive more use and, hopefully, will provide a better understanding to more people regarding the settlement and historic values of this area. It is imperative that existing and potential historic and archaeologic areas not be impaired by coal stripping or the development of associated facilities. The Historic Sites and Preservation Act and the Antiquities Acts should be implemented in their broadest sense.

Most Probable Forecast

Physical Resource Impacts

There is projected to be the following number of sections of land disturbed under this forecast:

1980	1985	2000
1½	11	34

The disturbance will be accompanied by one new export mine in 1980, two gasification plants in 1985, and one additional gasification plant and two power plants in the year 2000. Physical impact on the recreation resource base will be similar to those described under the Base Forecast, except there will be reason for serious concern for Class II and III recreation lands and for rivers and reservoirs by 1985. This concern will be magnified considerably by the year 2000 to include all existing and potential recreation resources in the county.

Use Characteristics

The 1970 population of 10,057 is projected to increase as follows:

1980	1985	2000

Impacts will be similar to those under the Base Forecast, except magnified. By the year 2000, the impact on game animals and fish may cause a reduction in permits available or in lower game bag limits in order to protect the resource. The need for more urban recreation facilities will become greater as will the need for facilities to accommodate non-urban recreationists. By 2000 or before, some of the more fragile areas may need to have their use restricted to protect the resource.

Legal Aspects

Problems will be similar to Base Forecast except more complex as development occurs and the population increases.

Economic Aspects

Similar to Base Forecast, but opportunities for benefits to the private sector and costs to governmental agencies providing recreation opportunities will be greater, starting in 1985 and increasing through 2000.

Historic and Scientific Impacts

Similar to Base Forecast, however, the construction of the two gasification plants in 1985 will increase the chance that irreversible changes will begin to occur to the historic character of the area. Also, there will be increasing concern that specific historic or archaeologic sites will be impaired or lost.

Extensive Forecast

Physical Resource Impacts

There are projected to be the following number of sections of land disturbed by coal mining and related development:

1980	1985	2000
5	16	68

This development would include one new export mine and one gasification plant in 1980, an additional export mine and two more gasification plants in 1985, and five new export mines, two power plants, and six more gasifications plants in the year 2000. Impacts will be similar to those previously mentioned under the other forecasts, however, they will be greatly magnified by the year 2000. Nearly all of the existing and potential recreation resources could be seriously impacted by that date. Of special concern would be alterations that may occur to the Tongue River and Reservoir, since this will be the locale of a majority of the development. Every possible precaution must be taken to protect these resources. Since strippable coal occupies such an extensive area throughout the three-state area, it is essential and only common sense that areas selected for development be developed on a priority basis. All areas that are unique or scarce and of high quality should be selected for development only after all other areas have been mined and other less damaging fuel sources have been exploited.

Use Characteristics

Under the Extensive Forecast, the 1970 population of 10,057 is projected to increase as follows:

1980	1985	2000
	(DATA UNAVAILABLE)	

Impacts will be similar to those described under the other two forecasts, except serious impacts may begin to appear as early as 1980, especially along the Tongue River and vicinity. By 1985 there will be serious impacts occurring on most recreation resources in the area, especially to consumptive uses, such as hunting and fishing.

Legal Aspects

Similar to Base and Most Probable Forecasts except greatly magnified, especially in the year 2000.

Economic Aspects

Similar to Base and Most Probable Forecasts.

Historic and Scientific Impacts

Similar to Base and Most Probable Forecasts, except greatly magnified. Serious concern for these kinds of resources will begin by 1985 and become crucial by the year 2000.

Rosebud County, Montana

Base Forecast

Physical Resource Impacts

Under this forecast there is projected to be the following number of sections of land disturbed by coal mining and related developments:

1980	1985	2000
4	10	30

In the year 2000 one powerplant would be built.

There are slightly over 3.2 million acres of land in Rosebud County. Of this amount, existing recreation resources include nearly 239,000 acres and potential recreation areas constitute another more than 235,500 acres. The nearly 233,700 acres of Natural Resource Lands and the almost 96,000 acres of Custer National Forest make up most of the existing recreation resource acreage. A small acreage of Tribal land and one small State Recreation Area make up the remainder. Most of the potential recreation acreage consists of the 235,523 acres of Tribal land. There are many historic sites, however, for which acreage figures were not available. Also, of great importance as a recreation resource is the Tongue River. Most other valleys, especially the Rosebud, also offer important recreation opportunities and merit protective measures.

Most of the strippable coal lies along the Tongue River valley, on the Custer National Forest lands in the southeast corner of the county, and on a mixture of private and Natural Resource Lands in the vicinity of Colstrip. Consequently, it can be assumed that these will be the areas most directly impacted by coal mining. Additional areas will be affected, however, by construction of powerplants, roads, railroads, aqueducts and powerlines. Although most of the recreation acreage is in a Class III category and appears to be in great abundance, it must be stressed that it varies greatly in quality and attraction as a recreation resource. It is unfortunate that most of the highest quality recreation lands are coincident of the area's most suitable coal strip mining. Serious concern should be given before 1980 to deterioration that may occur along the Tongue River if mining and development of service lines are allowed to occur in this area. The wooded slopes of the Custer National Forest are a scarce commodity in this general region, affording recreation opportunities not available elsewhere in the near vicinity, except on the nearby Tribal lands that are not open to the general public. Extensive strip mining of these wooded areas would severely diminish the acreage of high quality recreation resources in the county. Their replacement could not occur within the time frame of this study, if ever. Much of the area near Colstrip presents extensive scenic vistas, broken by colorful cliffs and steep-faced buttes. Although these more colorful and attractive features may not be economical to mine, their attraction may be decimated if great care is not taken in the placement and construction of facilities associated with the mining operation.

Use Characteristics

The 1970 population of is projected to increase as follows:

1980	1985	2000
	(DATA UNAVAILABLE)	

The coal company town, Colstrip, presently is undergoing a new surge of growth. The development of more such towns and enlargement of existing towns will occur as coal stripping and plant construction increases. The most desirable non-urban recreation resources available nearby to the influx of new people will be the Custer National Forest and the Tongue River. More extensive activities would occur on the Natural Resource Lands. Since the acreage of available high quality areas is relatively limited, conflicts may develop as the attempts to recreate on private and Tribal lands become more frequent. There already is a tendency among local land owners to post their land with no trespass signs and acts of vandalism are becoming more frequent. Special public relations efforts will be needed on the part of coal company personnel if these "signs" are to be prevented from growing into a major problem.

Legal Aspects

Existing laws relating to environmental protection will require application as developments are planned and approved. Also, the numerous historic sites in the area require that the Historic Sites Act, the National Historic Preservation Act and the Antiquities Act be enforced. Locally, there will be need for enforcement of zoning laws to control services resulting from population growth. As previously mentioned, law enforcement will become more of a problem as it relates to recreational activities.

Economic Aspects

Those in the private sector who provide services to the recreationists will have an opportunity to benefit as more people move into the area. Added costs, however, will be incurred by public agencies as more recreation facilities need to be developed and maintained. For instance, it is likely that more camping and picnic facilities will be needed in the Custer National Forest, trails may need to be developed, and more access points likely will be needed along the Tongue River. Likewise, the Bureau of Land Management will experience an increase in recreational use of their lands requiring them to build and maintain more facilities.

Historic and Scientific Aspects

There are a large number of historic sites in the county. It appears unlikely that there will be a significant impact on them before the year 2000 under the Base Forecast level of development. However, in 2000 with over 30 sections of land disturbed and one power plant built, there should be serious concern for these sites. Not only may some of the sites be lost, but infringing nearby development may completely alter the nature of the site. Also, with development of the year 2000 magnitude there will be a loss of the historic character of the general area.

Most Probable Forecast

Physical Resource Impacts

Under this level of development there are projected to be the following number of sections of land disturbed:

1980	1985	2000
4	14	53

This will be accompanied by one new export mine in 1980, two gasification plants in 1985, and two power plants and another gasification plant in the year 2000. The kinds of impacts will be similar to those described under Base Forecast, however, the impacts will become serious by as early as 1985. Although much of the development is proposed for the Colstrip area, the impacts on recreation resources will not be limited to that area. Service facilities are likely to impact recreation resources in several other parts of the county. Of special concern, again, will be the Tongue River Valley.

Use Characteristics

These will be similar to the Base Forecast, but will begin to cause serious impacts earlier-- probably by 1985 when the two gasification plants are built.

Legal Aspects

Similar to Base Forecast only problems will be magnified and occur earlier.

Economic Aspects

Similar to Base Forecast only problems will be greater and occur earlier.

Historic and Scientific Aspects

Similar to Base Forecast and becoming a serious concern by 1985.

Extensive Forecast

Physical Resource Impacts

Under this level of development the following number of sections of land would be disturbed:

1980	1985	2000
7	26	103

One gasification plant would be built in 1980, another three plus two export mines in 1985, and one power plant and three more export mines by the year 2000. Very serious impacts on the key recreation resources in the county would likely be unavoidable with this level of development. Most of the high quality recreation resources would be lost or seriously and irreversibly impaired by as early as 1985. This would especially be true of the Tongue River Valley. Other valley bottoms and streams also would likely be impaired --if not directly from strip mining, then most certainly by related developments.

Use Characteristics

Under the Extensive Forecast, the 1970 population of would increase as follows:

1980	1985	2000
	(DATA UNAVAILABLE)	

Impacts of increased participation in recreational activities will be similar to those discussed under the two forecast levels, except impacts would begin to cause problems before 1980. By the year 2000 many areas would be suffering from overuse unless careful controls are implemented. Management of non-facility oriented recreation activities on Natural Resource Lands would be difficult, both because of the fragile character of the resource and because of its fragmented pattern. The latter situation also makes it difficult for the recreationist to know when he may or may not be trespassing on private lands. Opportunities for consumptive uses, such as hunting and fishing-- particularly hunting of deer and antelope --will be far more limited than at present. Also, the present characteristics of hunting experiences will be vastly altered.

Legal Aspects

Similar to Base and Most Probable Forecasts.

Economic Aspects

Similar to other two forecasts, except greatly magnified by the year 2000. The present agriculturally oriented economy will be completely overshadowed by that tied to a single purpose --extraction of coal.

Careful planning and reclamation will be necessary to add other contributors to the economy to avoid leaving the area in economic collapse when coal ceases to be a prime energy source. Preservation of all of the area's high quality recreation resources could contribute to this more balanced economy. Decisionmakers should be aware that many of these resources are suitable for multiple-use and over a long period their preservation probably could be justified on a purely economic basis.

Historic and Scientific Aspects

Impacts will be similar to those discussed under Base and Most Probable Forecasts. However, with the likelihood that at least the equivalent of more than 103 sections of land will have been disturbed by mining and related development by the year 2000, it seems safe to assume that the historic character will be radically changed. It also seems likely that many of the historic areas will have lost much of their meaning and appeal because of encroachments that until recently have been foreign to the area.

REGION-WIDE RECREATION IMPACTS

A general overview of the recreation resource base is provided in the Regional Profile for Recreation--Results--, and will not be repeated in this section. An analysis of impacts resulting from coal and related development in the Northern Great Plains Resource Program study area would not be complete, however, if only the impacts within the study area were considered. Nearby is a wide variety of high quality recreation resources that most certainly will be impinged upon by any significant coal development and population growth in the study area. The following discussion will not dwell on impacts already discussed for the four sample areas, but instead will look at the total region and will include the sample area impact in this broader context.

Base Forecast

Physical Resource Impacts

An estimate of the amount of land that is likely to be disturbed by coal and related development under this forecast can best be illustrated in tabular form, including the number of new mines and plants:

	1980 (Acres)	1985 (Acres)	2000 (Acres)
Montana	3,766 (1P)*	9,803	30,403 (4P-2E)
North Dakota	4,047 (2E)*	8,209	22,274 (1P-1E)
Wyoming	1,424 (1E)	4,162	13,423 (1P-1E)
TOTAL	9,237 (1P-3E)	22,174	66,100 (6P-4E)

*P=New Power Generation Plant
E=New Export Mine

Since most of the coal development activity will occur in the four sample counties, it is there that impacts will be greatest. For example, there will be cause for serious concern about the small base of existing Class II and III recreation resources in Mercer and Oliver Counties and for streams in Rosebud County as early as 1980.

In Musselshell County, Montana, there is projected to be one export mine operating by 1980. It will disturb over 500 acres by the year 2000. With the more than 104,300 acres of National Resource Land and several small Class II areas, it is unlikely that any major impacts to these areas will occur. The Class V Lake Mason National Wildlife Refuge may receive some indirect impacts from an increase of people in the area.

In McCone County, Montana, one powerplant is projected for the year 2000. Beginning then, over 600 acres will be disturbed. There are over 202,000 acres of Natural Resource Lands in the county and three small reservoirs. There also is one existing outstanding natural area and three potential natural landmarks. It should be possible in locating the mine, the powerplant, and associated facilities to avoid impairment of these areas. Some adverse impacts, however, will result from the increased use of these areas by people associated with this development.

In Richland County, Montana, one powerplant is projected for 1980. An estimated 572 acres would be disturbed by the year 2000. There are several Class II and III areas in the county, the largest being more than 52,800 acres of Natural Resource Lands. There also is the Fort Union Trading Post National Historic Site and some potential historic sites associated with the Lewis and Clark Expedition. It is unlikely that the Class III lands will be significantly impacted, but special care should be taken to avoid deterioration of the historic sites, either from the mine and powerplant or from related service facilities. Some adverse impact will result from increased recreational use of the resources by people associated with the mine and powerplant.

In Sheridan County, Wyoming, an export mine is projected to begin in 1980. By 2000, nearly 750 acres would be disturbed. There is a large number of Class III areas in the county. By far the largest is the nearly 402,350-acre Bighorn National Forest and the nearby 50,700 acres of Natural Resource Land. There also is one existing historic site and one National Historic Landmark and 18 potential historic sites. It is unlikely that most of these areas will be directly impacted from the mine. Care must be taken, however, in locating any associated features to avoid impairment or loss of any of the Class VI areas.

In Adams County, North Dakota, one export mine is projected to open by 1980. By the year 2000, an estimated 2375 acres of land would be disturbed by the mine. There are several small Class II and III recreation areas in the county. Most are associated with urban development or small reservoirs. Except for visual impacts and those resulting from increased use of these existing areas, it appears there will be little adverse effect from this mine.

However, even though no archaeologic sites have been identified, care should be taken in an operation of this magnitude to identify and protect any that thus far have been undiscovered. Also, since the county does not abound with recreation sites, it would seem wise to reclaim part of the mined land for recreation use.

In McHenry County, North Dakota, one export mine is projected to open by 1980. By the year 2000, nearly 700 acres will have been disturbed. The only identified existing areas are 3,233 acres of Natural Resource Land and two small U.S. Forest Service areas, all Class III. In addition, there are three potential outstanding natural areas. It is difficult to forecast the impact of the mine on these resources, since the exact locations are not known. If not located directly on these resources, it is likely there will be little adverse impact other than visual and that resulting from increased recreation use by those associated with the mining activity.

In Slope County, North Dakota, one export mine is projected to open by the year 2000, with 856 acres of disturbed land. The county has several Class II and III areas. By far the largest is the 138,357-acre Little Missouri National Grassland, followed by the 181-acre Cedar Lake Game Management Area. All others are small and in urban areas or associated with small reservoirs. In addition, however, there are two existing large National Wildlife Refuges. Also, there are four potential outstanding natural areas, two potential scenic drives, and the Little Missouri Scenic River.

The latter has been suggested for addition to the list of rivers under Section 5(a) of the Wild and Scenic Rivers Act to study for possible addition to the National System. Without knowing the exact location of the mine and its service facilities, it is difficult to judge possible impacts. It is certain that recreation use pressures will increase and that some areas may be impaired visually. Special care should be taken in all development associated with the mine to avoid destruction or impairment of the high quality recreation resources.

In addition to the above-mentioned recreation resources that may be impaired, it must be mentioned that extension of service lines across other counties may adversely impact recreation resources that are located there. Special care must be taken in the placement and construction of these lines to avoid unnecessary impacts, especially on Class IV, V, or VI areas and on stream valleys. All are almost impossible to replace once they are lost.

Use Characteristics

The 1970 population of   in the study area is projected to increase as follows:

1980	1985	2000
	(DATA UNAVAILABLE)	

It is likely that most of this influx will locate near the areas projected for extensive coal strip mining and that the majority will live in urban areas, either in new towns or in existing towns like Gillette, which is projected to increase by several thousand people. These concentrations of people directly involved in coal mining and its related developments will generate the development of a variety of service businesses which may or may not be located near the strip mining activity and power and gasification plants. Service centers like Billings, Bismarck, and Casper will grow because of the expanded services they will be called upon to provide. These will range from governmental services and personnel to the distribution of various kinds of commodities.

If the foregoing assumptions are valid, then it is clear that recreational use pressures will develop and occur throughout all of the study area and on adjoining areas and will not be limited to the vicinity of the four sample county areas. It, therefore, will not be a matter of providing recreation opportunities only in the vicinity of the four sample counties, although that will be important--especially for day-use activities, but of planning for and developing facilities, urban and non-urban, throughout most of the study area and on nearby lands.

Most of the recreation resources in the study area are fragile and cannot withstand prolonged intensive use. An added complication is that most require a long period for renewal once they have been damaged. Damage will result not only from the various coal-related developments, but also from increased use by recreationists. The costs of developing and maintaining new recreation facilities and of controlling increased use pressures on the extensive Natural Resource Lands, National Forests, National Parks, and, to a lesser extent, on National Wildlife Refuges will be significantly increased.

Recreational impacts will increase disproportionately on water areas--rivers, lakes, and reservoirs. The larger and more scenic water bodies and rivers will be the prime attractions, but as pressures increase, there likely will be an increase in use of the less attractive small water bodies and stream valleys. Granted, there are large reservoirs in a few locations in and nearby the region. These, however, either are not readily available, because of access or distance, or a large part of their surface is not effective recreation acreage, primarily because of safety. Therefore, despite the large acreages of water surface, there will be a great need to protect the relatively few streams, lakes, and reservoirs in the region from development and make them available to recreationists. From a short-term view it may seem prudent to use valley bottoms for coal-related developments, but in the context of total long-range economic impact, it is essential that these areas be protected from development. In other words, they must be viewed not for their short-term single-purpose use for coal development, but rather in the light of their multiple use values and what the character of the region is desired to be when coal no longer is sought as a key energy source.

Legal Aspects

Most legal concerns relating to recreation have been mentioned in the sample county discussions. It should be stressed, however, that many other laws than those mentioned there must be recognized and interpreted as to how they may affect various plansof development.

Some of these are listed in the section on Constraints. Since water is the key to the amount, kinds, and locations of development that occur in this region, many of the legal problems will relate to the uses that can be made of available water supplies. Examples will involve transbasin transfers; problems associated with interstate compacts; water rights - governmental, private, tribal; beneficial uses; season availability; priorities for use; environmental problems; etc. Other questions will include the effects of such laws on the Land and Water Conservation Fund on existing federally cost-shared recreation facilities, effect of the Wilderness Act on cloud seeding, effect of the Transportation Act on route locations, effects of Dingell-Johnson and Pittman-Robertson Acts on proposals to alter wildlife habitat, effect of Wild and Scenic Rivers Act, etc.

Economic Aspects

Again, the sample county discussions have covered most of the kinds of economic impacts that may occur, the only significant difference here being the increase in magnitude of benefits and costs when related to the whole region. One major difference might be, however, that many of the costs will be incurred quite far from the mining activity by communities or people who will stand little chance to profit from the mining activity itself, at least not directly. Some in the private sector who provide services, however, will benefit.

Historic and Scientific Impacts

Impacts on the historic, cultural, and scientific values of the region will likely be more severe and long lasting than any of the other impacts. Even with successful reclamation of the mined lands, it is unlikely that the present characteristics of the region could be retained. Many of the unique historic and scientific features, of which the region abounds, will be either directly or indirectly impinged upon by mining-related activities. Most of these are likely to be irreversible actions. Since in its broadest sense the region is unique, decisions to alter its unique character are of a national interest and should not be made only in the interest of serving relatively short-term interests or the desires of a few people.

Most Probable Forecast

Physical Resource Impacts

An estimate of the amount of land that will be disturbed by mining and related developments under this forecast is as follows:

	1980 (Acres)	1985 (Acres)	2000 (Acres)
Montana	4,077 (2E-1P)	16,744 (1E-3G)*	58,982 (2E-3G-4P)
North Dakota	4,047 (2E)	12,304 (1E-2G)	61,777 (5G-6P)
Wyoming	1,707 (2E)	8,238 (1E-2G)	26,668 (2E-1G-1P)
Total	9,831 (6E-1P)	37,286 (3E-7G)	147,427 (4E-9G-11P)

*G=New gasification plant

Impacts of the above scale of development will be similar to those described under the Base Forecast, except that more recreation resources in more counties may be affected. In the sample counties there should be serious concern for damage that may occur on Class II and III lands as early as 1985. In Rosebud County, Montana, there may be serious impacts on potential Class III and Class VI areas and irreversible damage may have occurred to the Tongue River by 1985. In Richland County, Montana, a powerplant is projected to open in 1980, with 572 acres estimated to be disturbed by the year 2000. The county has over 52,800 acres of Natural Resource Lands, the nearly 1,400-acre Fox Lake Game Bird Management Area, the 22-acre Nohly Bridge Recreation Site, and the Gartside Dam Fish Access. Also here is the Fort Union Trading Post National Historic Site. There also is a small amount of tribal land and there are potential historic sites associated with the Lewis and Clark Expedition. With careful planning, direct impacts on these resources likely can be avoided. However, indirect visual impacts will result and impacts will result from increased recreational use generated by people associated with the powerplant.

In McCone County, Montana, one powerplant is projected to begin operation by the year 2000. An estimated 609 acres will have been disturbed. There are several existing Class III areas in the county, but by far the largest is the more than 202,000 acres of Natural Resource Land. There also is one Class IV area, the Bug Creek Fossil Area National Landmark. Potential recreation resources consist of nearly 1,800 acres of tribal land and outstanding natural areas. Careful planning will prevent direct impact on these areas. However, the plant, the powerline, and the increased population will cause indirect impacts, especially visual and recreation use pressures.

In Musselshell County, Montana, one export mine is projected to open by 1980, with an estimated 527 acres to be disturbed by 2000. There are several small Class II areas and over 104,300 acres of Natural Resource Land. There also is one Class V primitive-type area, the 18,643-acre Lake Mason National Wildlife Refuge. Careful planning should avoid direct impact on these areas. There will be some visual effect on the area near the mine and roads and railroads and possibly some increased recreation use impact generated by people associated with the mine.

In Powder River, Montana, one gasification plant and one export mine are projected for the year 2000. These would result in an estimated 1,688 acres of disturbed land in that year. There is extensive recreation acreage in the county consisting of the Natural Resource Lands, 257,836 acres, and the Custer National Forest, 341,946 acres. There also are several potential outstanding natural areas and historic sites. Development of the magnitude projected, along with the associated service facilities, will cause both a direct and an indirect impact on some of these resources. Special planning will be needed to avoid impairment of those features that are unique or of the highest quality.

In Converse County, Wyoming, a gasification plant is projected to begin operation by 1985. An estimated 3,516 acres will have been disturbed by the year 2000. The county contains extensive recreation acreage. The most extensive is the nearly 129,000 acres of Natural Resource Land, the nearly 186,000-acre Thunder Basin National Grassland, and the nearly 79,300-acre Medicine Bow National Forest. There also are two outstanding natural areas, Fort Fetterman and Ayers Park (Natural Bridge). Potential areas consist of State Highway 94, a scenic road, two natural landmarks, and two historic sites. Adverse impacts will result from a development of this size. With nearly five and a half sections of land disturbed, there will be not only a loss of general recreation land and a change in the present character of the area, but indirect impacts on nearby areas. Care will be needed in locating the mine and its related service facilities to avoid impairment of unique and high quality areas.

In Johnson County, Wyoming, a gasification plant is projected for operation by the year 2000. An estimated 1,228 acres will be disturbed by then. There is extensive Natural Resource Land, over 538,400 acres, and the more than 331,600-acre Bighorn National Forest in the county. In addition to some small Class II and III areas, there are two historic areas, Fort Phil Kearny National Historic Landmark and Fort Reno Historic Site. Several potential areas also are in the county. These are the 960-acre Petrified Forest Monument, the 22,400-acre North Fork Primitive Area, the

Red Fork Fossil Area, a 4-mile segment of scenic highway (Story to I-90S), and eight historic sites. With this extensive an acreage of recreation land, it appears that adverse impacts will be unavoidable. Even though the roughly two sections of land may seem insignificant, care should be taken to avoid impairment of the highest quality and unique areas. Also, to be recognized is the impact on the general area that will result from related service facilities and increased recreation use pressure.

In Sheridan County, Wyoming, one export mine is projected to open by 1980 and another by the year 2000. An estimated 815 acres of land would be disturbed by 2000. There are numerous Class II and III areas in the county. By far the largest is the almost 402,350-acre Bighorn National Forest and the nearly 50,670 acres of Natural Resource Land. There are two historic sites. The county also has 18 potential historic or archaeologic areas and several Class II and III areas. It appears that serious impacts of these resources can be avoided with careful planning. However, measures will have to be taken to protect the historic and archaeologic areas from impairment caused by the increase in people in the area.

In Dunn County, North Dakota, one gasification plant is projected for 1985 and two more in the year 2000. An estimated 16,400 acres would be disturbed by 2000. The largest recreation area in the county is the 6,000-acre Little Missouri Bay State Park. There are several small urban-oriented Class II areas and one small historic site, Killdeer Battlefield. Potential areas include two outstanding natural areas, the largest of which is the 20,000-acre Killdeer Mountains. There also are more than 199,750 acres of tribal land. Of importance is the Little Missouri River, which is under consideration for study to determine its suitability for addition to the national system of wild and scenic rivers. With almost 26 sections of land estimated to be directly disturbed by the three projected plants by 2000, it is difficult to see how serious impacts on these resources can be avoided. There is considerable danger that some of the potential areas will be irreparably damaged or lost. Special measures should be initiated to avoid deterioration or loss of these high quality and unique areas, especially the Little Missouri River.

In McLean County, North Dakota, there are two gasification plants projected for 2000, with a disturbance of an estimated 3,732 acres. There is a large number of existing recreation areas in the county, some or all of which are likely to be adversely impacted, either from mining or increased use pressures (see Regional Profile Table). These include a number of Class V and Class VI areas. The county also has 91,563 acres of potential recreation area in tribal land.

In McHenry County, North Dakota, one export mine is scheduled for operation in 1980. By 2000, an estimated 695 acres will have been disturbed. The county has three Class III areas, the largest being 3,233 acres of Natural Resource Land. There also are three potential outstanding natural areas. It appears that proper planning and location of the mine and related service lines could avoid serious impairment of these resources. Special care should be taken to protect the unique areas from misuse, however.

In Adams County, North Dakota, one export mine is projected to open in 1980. By 2000, an estimated 2,375 acres will have been disturbed. The county has several small Class II and III areas, mostly in urban areas or associated with small reservoirs. It is doubtful that direct impacts will occur, but almost certain that some areas will be indirectly impacted, either visually or from increased use pressures.

In Slope County, North Dakota, one export mine is projected for 1985 and one powerplant by 2000. An estimated 2,354 acres of land would be disturbed by that date. The county contains several Class II and III areas, the largest being the 138,357-acre Little Missouri National Grassland. There also are two Class V National Wildlife Refuges, Stewart Lake, 2,230 acres, and White Lake, 1,040 acres. Potential areas include the 1,600-acre Chalky Buttes Park Area, four outstanding natural areas, and the Little Missouri River. The latter, as mentioned elsewhere, is a possible candidate for the national wild and scenic rivers system.

In Hettinger County, North Dakota, two powerplants are projected for the year 2000. An estimated 1,562 acres would be disturbed by then. The county has 13 small Class II and III areas. Most significant impacts likely will result from increased use pressures.

Care in the placement of powerlines and other service facilities will be necessary to avoid damage to these areas.

In Billings, County, North Dakota, a powerplant is projected for the year 2000, with an estimated 760 acres of land disturbed. The County contains several recreation areas. By far the largest is the 289,986-acre Little Missouri National Grassland and the over 46,000-acre Theodore Roosevelt National Memorial Park. Also important is the 178-acre DeMores Historic Site. The county also has one potential natural landmark, Bullion Butte, and one scenic drive, East River Road - Medora to Amidon. It also includes a segment of the potential Little Missouri Scenic River. Special measures should be taken to avoid direct impacts on the high quality and outstanding natural areas. The population increase will result in more recreation use pressure.

Use Characteristics, Legal, Economic, Historic and Scientific Aspects

Impacts relating to these concerns have been adequately discussed under the Base Forecast for the region and in the sample area discussion. The only difference, generally, will be the increased scope of impact of each of these subjects.

Extensive Forecast

Physical Resource Impacts

An estimate of the amount of land that is projected to be disturbed by mining and related development under this forecast is as follows:

	1980 (Acres)	1985 (Acres)	2000 (Acres)
Montana	9,190 (2E-3G-1P)	30,293 (4E-5G)	124,783 (14E-7G-3P)
No. Dakota	11,728 (2E-4G)	34,413 (1E-2G)	138,968 (1E-11G-6P)
Wyoming	1,707 (3E)	16,125 (5E-6G)	66,540 (19E-3G-1P)
Total	22,625 (7E-7G-1P)	80,831 (10E-13G)	330,291 (34E-21G-10P)

In 1980, the sample counties of Rosebud, Mercer, and Oliver will have developments extensive enough to cause serious concern for recreation resources. By 1985, there will be a significant and irreparable loss of Class III lands and of some of the highest quality waterways, historic, archaeologic, and scientific features.

In Powder River County, Montana, one gasification plant is projected to be built in 1980 and one more in 2000. One export mine is to open in 1985, with six more to follow in 2000. An estimated more than 11,500 acres will be disturbed by 2000. It is likely that this magnitude of development would have serious impacts on many parts of the extensive acreage of Natural Resource Land and the Custer National Forest. There also would be considerable chance that part of all of the two potential outstanding natural areas and the four historic sites may be lost.

In Richland County, Montana, one powerplant is projected for 1980, with no other mines slated for later time frames. An estimated

572 acres would be disturbed by 2000. There are large acreages of Class III land and the Class VI Fort Union Trading Post National Historic Site that could be impaired, if not directly from the mine or powerplant, then from the powerlines or other associated developments.

McCone County, Montana, and Musselshell County, Montana, conditions will be the same as in the Most Probable Forecast.

In Custer County, Montana, three export mines are projected for the year 2000. They would disturb an estimated 2,571 acres by that date. There are a number of small Class II areas and 341,475 acres of Natural Resource Land in the county. There also are four potential historic sites in the county. This magnitude of stip mining likely will directly impact at least some of the Natural Resource Land and will change the present character of the immediate and nearby recreation areas. Care should be taken to avoid infringing on the historic sites, either by the mine or its related developments.

In Sheridan County, Wyoming, one export mine is projected to open in 1980, two more in 1985, and two in the year 2000. An estimated 4,382 acres would be disturbed by 2000. There are several Class II and III areas in the county, including the 402,349-acre Bighorn National Forest and the 50,668 acres of Natural Resource Land. Also, there are two small historic sites. Potential areas include 18 historic and archaeologic sites and several Class II and III areas. The greatest impacts will relate more to a change in the general character of the areas' resources.

These will include visual changes and impacts resulting from increased recreational use of resources in the area. This assumes that planning and control of development will occur in a way to avoid loss or impairment of the large number of historic sites.

In Converse County, Wyoming, one gasification plant is projected for 1985 and one export mine by 2000. This would result in an estimated 4,284 acres disturbed by 2000. The county contains a large acreage of recreation resources, especially Class III lands. The largest is the Thunder Basin National Grassland of over 185,700 acres, followed by nearly 128,900 acres of Natural Resource Land, and nearly 79,300 acres of the Medicine Bow National Forest. There are two small outstanding natural areas, Fort Fetterman, 60 acres, and Ayers Park (Natural Bridge), 20 acres. There also are several potential recreation areas consisting of historic sites and outstanding natural areas and one scenic drive.

By the year 2000, it is likely that some of these resources will be adversely impacted. This may result either from the extensive strip-mined area, from the plant and its related features, or from the increased number of people in the area.

In Johnson County, Wyoming, one gasification plant is projected for 1985, two more by 2000, along with two export mines. This would result in an estimated 4,796 acres disturbed. There is a very large acreage of Class III land in the county. Most extensive is the Bighorn National Forest, 331,601 acres; Natural Resource Lands, 202,084 acres; Cloud Creek Recreation Complex, 141,255 acres;

and Hole-in-the-Wall Recreation Complex, 195,070 acres. There also is the 3-acre Fort Phil Kearny National Historic Landmark and the 14-acre Fort Reno Historic Site. The county also has a large number of potential areas that are listed in the table of potential areas.

By 2000, there will be serious concern for deterioration of loss of many of the recreation areas in Johnson County. Special care will be needed in the location and development and operation of the gasification plants and their related facilities. Also impacting the recreation areas will be the people associated with these developments.

In Dunn County, North Dakota, two gasification plants are projected for 1980 and five more by the year 2000. An estimated 41,839 acres will be disturbed by 2000. There are a large number of Class II and Class III areas in the county. By far the largest is the 483,061-acre Lake Sakakawea, of which 370,300 acres are water. Also occupying considerable area is the 15,989 acres of Natural Resource Land and the 6,000-acre Little Missouri State Park. The county has only one historic site, the one-acre Killdeer Battlefield. In addition to the aforementioned existing recreation areas, there is a sizable acreage of recreation resources. Tribal land occupies nearly 199,800 acres, and the Killdeer Mountains are a potential outstanding natural area of 20,000 acres. There also are two potential scenic highways, the Killdeer Mountain Gap Road and Highways 22-23, Killdeer to New Town.

With seven gasification plants projected and over 65 sections of land disturbed by 2000, it is likely that some or all of the resources will experience severe impacts and that the entire character of the general area will be altered. Great care will be needed in planning, design, and development and operation of these plants and their related development to ameleiorate these impacts. Special care should be taken to protect the shoreline of Lake Sakakawea and to avoid excessive fluctuation of the water level.

In McLean County, North Dakota, one gasification plant is projected for operation in 1985 and two more in the year 2000. By 2000, an estimated 15,888 acres will be disturbed. The county has a large number of Class II and III areas; see the Regional Profile tables. There also are seven Class V National Wildlife Refuges. The only identified potential recreation resource is the 91,563 acres of traval land. It is safe to assume that several of these areas will be adversely impacted by this scale of development. It is likely that some areas will be lost, while others will suffer from indirect impacts. The general character of the area will be changed and recreation use pressures will increase.

In Slope County, North Dakota, one export mine is projected for 1985 and one powerplant and a gasification plant for the year 2000. An estimated 4,520 acres would be disturbed by 2000. The county has several Class II and III areas, the largest being the 138,357-acre Little Missouri National Grassland. There also are two Class V National Wildlife Refuges. Potential areas consist of the 1,600-acre Chalky Buttes Park Area, four outstanding natural areas, two scenic drives, and a segment of the Little Missouri River, a candidate for study for addition to the national system of wild and scenic rivers. There will be adverse impacts on at least part of these resources from this scale and kind of development. Special care must be taken in locating the plants, the powerlines, and aqueducts and other services to avoid direct loss or impairment of all high quality and unique areas. Even so, there will be visual deterioration and an overall change in the present rural character of the area. Recreation use pressures also will be considerably increased.

In Stark County, North Dakota, one gasification plant is projected for the year 2000, with a disturbance of 1,953 acres. There are a large number of small Class II areas and three Class III areas. Most are associated with urban areas or small reservoirs. There also is one potential outstanding natural resource, the 640-acre Little Badlands Park Area. Careful planning should be able to avoid direct impairment of these resources. There will, however, be an increase in recreation use generated by the people associated with the mine and plant. Special measures should be taken to protect the unique potential area.

Billings, Hettinger, and McHenry Counties, North Dakota, developments and impacts are as described under the Most Probable Forecast.

Use Characteristics, Legal, Economic, Historic and Scientific Aspects

Impacts relating to these concerns have been adequately discussed under the Base Forecast for the region and in the sample area discussion. The only difference, generally, will be the increased scope of impact of each of these subjects.

SUMMARY

The analysis of impacts that may result from each level of development is necessarily repetitious. Therefore, a summary of some of the more salient points is warranted.

In the broadest sense, nearly all of the region can be considered a recreation resource. From a narrower view, designated and potential recreation resources are scattered within and adjacent to the study area. These range from extensive natural environment areas to the more unique outstanding natural areas and the historic, archaeologic, and cultural areas.

It became apparent while analyzing the effects of coal strip mining that the analysis would have to include recognition of impacts that would result from associated developments and from an increased population. Also, that impacts on recreation resources would result not only from physical disturbances of the land, but also from recreation use pressures, legal related concerns, economic values, and danger to historical and scientific areas.

As would be expected, the most severe and direct impacts will occur in the near vicinity of the major areas projected for strip mining and development of power and gasification plants. Other areas that will be more indirectly impacted are the several high quality recreation areas adjacent to the study area.

The most important and longest lasting impact will be the change that will occur to the overall region. For instance, if the scale of development projected for the year 2000, Extensive Forecast, occurs, there is little likelihood that much semblance of the present way of life will remain in the area. More importantly, decision-makers must realize that the year 2000 impacts are in a sense just a beginning since the majority of development is projected to begin then. It is the impacts that will occur from 2000 to about 2025 that will be many times more severe. Unfortunately, they are not generally treated in this study.

There are several adverse impacts on recreation resources that recur throughout the analysis. The most direct impact is the acreage of various types of recreation areas that will be altered by the disturbance of land during the mining process and by the construction of related service facilities. These may include aqueducts and pipelines, powerlines, roads, railroads, airfields, and new towns or suburbs.

There are other adverse impacts that are more indirect but just as significant, since they will occur over a much larger area. These include recreation use pressures and conflicts of interest that will result from a population influx; changes to the region's basic economy and, more directly, increased costs for acquisition and development and operation and maintenance of recreation facilities; legal impacts that range all the way from local law enforcement problems to interpretation and application of Federal legislation; and impacts that will occur on historic and scientific features. The latter will range from loss or deterioration of specific sites to an irreversible change in the overall character of the area as it has been known in the past and which mainly exists today.

A presently unknown impact that may be more pervading and not be recognized for several years is the effect on flora and fauna of minerals released by burning coal. Although these would be changes in the ecological chain, they also would affect the recreation resource base.

CONCLUSIONS

Several conclusions have resulted from the foregoing analysis. The first ones listed are not limited to recreation interests, but their importance warrants their mention here with the hope that others will also have made the same observation.

An analysis of coal development impacts in the NGPRP study area is difficult, since it is done without recognition of what part the energy produced may or may not contribute to the national energy needs, by time frame. There is urgent need for a coordinated, on-going, national study of all present and projected energy sources. The base data would probably have to be computer oriented and use the most sophisticated data gathering methods. A national policy could then be developed that would state which energy sources should be developed to meet the national energy during specific time frames. This would be done in recognition of international supplies and needs.

In a more limited sense, it was concluded that a complete analysis of coal development impacts could only be done with recognition of other major developments projected to occur in the region. For instance, the impact of coal development in a given area may not seem great, but impacts could be severe when coupled with nearby non-coal related development. A total comprehensive study is needed to surface these impacts. Considerable data are available, but many information gaps exist. With the rapid changes occurring in conjunction with the unique, fragile, high quality resource, there is great need for an on-going study program of the area.

The majority of the projected developments are scheduled to begin in the year 2000. A realistic analysis of impacts cannot be made without recognizing the scale of development that would follow 2000.

It is evident that since the extensive coal strippable area occurs on lands that vary greatly in quality and uniqueness that an energy development policy is urgently needed that will establish areas for development by priority. In this way, all high quality and unique areas could be reserved from coal development until last when, hopefully, other sources of energy will have been developed.

Land use planning should be accomplished as soon as possible in each of the involved states to provide a basis for controlling coal within the context of other development.

The next updating of the State Comprehensive Outdoor Recreation Plan for each of the involved states should include recognition of the impacts that coal development may have on the recreation resource base and on existing and needed recreation facilities. It also should consider the increased need for funding and possible changes in laws that may be needed to accommodate a rapid growth in the area.

Demands for water to support coal and the other developments in the area may have considerable impact on this key resource for many recreation activities. The BSF&W has established an extensive program to determine instream flows suitable for fish. A similar program is needed to determine flows and reservoir water levels most suitable for recreation activities.

The EPA has established a program to monitor air quality resulting from burning coal. The effects minerals released by burning coal will have on the flora and fauna that constitute the recreation resource base is not known. The BOR should establish a program to insure that these interests will be served by the EPA or other programs.

Information is scarce on the role the private sector can or should be expected to play in providing outdoor recreation opportunities to the people in this area. A program should be established to develop the necessary data upon which to base decisions.

Hopefully, the need for more complete socio-economic information as it relates to recreation will be discussed by the Socio-Economic Work Group. Its importance warrants mention here that a program is needed to better understand these influences.

The exact location and boundaries of many existing and potential recreation resources could not be determined for this study. A program is urgently needed to identify these resources so that plans can be made to avoid their destruction. This information is especially needed in the areas where coal development is most imminent.

A final observation is that in general and on an extensive basis, a stripmined coalfield is a transition from a high quality condition to something much less. Overall, it will result in a loss to the Nation and in a sense, the world, of irreplaceable resources and intangible values.

Discussion Draft
March 1974

IMPACTS OF COAL DEVELOPMENT ON AGRICULTURE

I. INTRODUCTION

Agriculture is the principal industry of the area under consideration in the Northern Great Plains. Characteristically, the principal pursuits are large wheat or cattle ranches, supplemented by other crops and livestock to a lesser extent. This analysis reports the probable impact of projected levels of coal development over three time frames.

II. ASSUMPTIONS

In addition to other basic assumptions made for the Surface Resources Work Group, the following assumptions are made concerning the estimates of impacts of coal development on agriculture.

1. Campbell County, Wyoming. Mining disturbance will affect only productive rangeland. No cropland and no forest land will be affected.

   Big Horn County, Montana. Mining disturbance will affect land resources according to the percentages shown: rangeland--80, forest land--10, cropland--10, divided equally between wheat and alfalfa.

   Rosebud County, Montana. Mining disturbance will affect land resources according to the percentages shown: rangeland--80, forest land--15, and cropland--5 (wheat).

   Mercer and Oliver Counties, North Dakota. Best estimate available for probable land resource disturbance is shown percentagewise as follows: Mercer County, 55--rangeland, 45--cropland; Oliver County, 70--rangeland, 30--cropland. Assume for purpose of analysis, combining both counties: 60 percent rangeland, 40 percent cropland.

Assume cropland affected thusly: one-half wheat, one-fourth oats, one-fourth alfalfa hay.

2. Assume 5 years as time requirement to return mined acreage to stable productive cropland. Assume 5 years to regenerate, by planting, forest land. Assume 10 years to return rangeland to stable and productive grazing condition. For such uses as wildlife habitat, scenery, etc., assume a minimum of 25 years.
3. The land to be disturbed in each state, other than the sample counties, is broken into the following major land uses:

State	Pasture & rangeland	Wheat	Alfalfa	Barley	Oats	Forest
	Percent					
Montana	77	12	3	4	-	4
No. Dakota	40	36	8	4	9	3
So. Dakota	83	6	7	-	3	1
Wyoming	87	1	3	-	-	9

4. No irrigated land will be disturbed by the mining activity.
5. Three acres per animal unit month grazing for entire area and an 8-month grazing period.
6. By 1980, 5 years of mining activity will have taken place.

7. Acreages for plant sites, mine facilities, and reservoirs are fixed, and that all of this land disturbance will have taken the land out of production by 1980 and it is not reclaimable before the end of the time frame.

III. RESULTS

Throughout this discussion, the reader should bear in mind that the area of consideration relates to 63 counties previously enumerated which comprise portions of four states. Within the Northern Great Plains Resources Program study area, there are 37,920 farms. They vary greatly in size, depending largely upon the intensiveness of the particular agricultural pursuits. The average size by states is: Montana--3,771 acres; North Dakota--1,294 acres; South Dakota--3,598 acres; and Wyoming--6,329 acres.

Land estimated to be disturbed by all counties using the time frames of 1980, 1985, and 2000, according to the "Base", "Most Probable", and "Extensive" development, is:

	FORECAST								
	Base			Most Probable			Extensive		
	1980	1985	2000	1980	1985	2000	1980	1985	2000
Fixed acres out of production for plant site, etc. (acres)	4,040	4,040	4,040	25,333	25,333	25,333	60,651	60,651	60,651
Crop and rangeland being disturbed (acres)	19,009	33,530	33,530	64,961	104,307	104,307	148,084	247,893	247,893
Total acres disturbed	23,049	37,570	37,570	90,294	129,640	129,640	208735	308,544	308,544

Under the most probable level of development, an estimated 130,000 acres, or 14 percent, of all land in the Northern Great Plains Program area will be out of production for each year from 1985 to 2000. Of course, Campbell County, Wyoming, Big Horn and Rosebud Counties in Montana, and Mercer and Oliver Counties in North Dakota, will suffer the greatest impact. However, adjustments will need to be made throughout the area.

Starting in 1980, the annual impact (excluding plant sites) on crop production under the "Most Probable" forecast for development is estimated as follows:

Crop	Acres	Average yield 1971	Estimated total production lost per year	
Wheat	13,807	20 bu/acre	276,140	bu
Barley	1,205	37 bu/acre	44,585	bu
Oats	3,866	50 bu/acre	193,300	bu

The loss in wheat production is only slightly more than 2 percent of total wheat production in the area.

Under the "Most Extensive" development there would be an estimated annual crop loss (excluding land used for plant siting) as follows:

Crop	Acres	Average yield 1971	Estimated total production lost per year	
Wheat	28,400	20 bu/acre	568,000	bu
Barley	2,878	37 bu/acre	106,486	bu
Oats	7,328	50 bu/acre	366,400	bu

The loss in wheat production at this level of development is about 4.5 percent of total wheat production in the area.

Rangeland takes a time frame of 10 years before it can be reestablished for grazing purposes. Under the "Most Probable" forecast for development, by 1985 there would be 78,693 acres of rangeland out of production each year until the year 2000. (This excludes land lost to plant site construction.) If we assume three animal unit months and an 8-month growing season, the impact area will support a carrying capacity of 3,300 fewer cattle than it had prior to coal development. Under the "Most Extensive" development, there would be an annual reduction in carrying capacity of 8,317 head. When the land used for plant sites is included, the carrying capacity is reduced another 14 percent, or 1,000 head. The loss, in numbers, of livestock is less than one-half of 1 percent for the entire area.

Any attempt to place a dollar value on the loss of production at any one point in time could lead to some erroneous conclusions about the economic loss from agricultural production. The two principal agricultural commodities--beef and wheat--have been subject to wide price fluctuations within the past year. Any attempt to project the price and changes, in per unit yields, would require considerably more time and sophisticated techniques than are presently available in the preparation of this discussion paper.

IV. STRENGTHS OF THE ANALYSIS

The estimates are based upon available information, and, in most cases, estimates on the loss of production will generally be conservative. The estimates provide the reader some perspective on the magnitude of the acreage loss in the area.

The analysis on the five sample counties allows for a more localized look at the areas of more intense development.

V. WEAKNESSES IN THE ANALYSIS

The estimates consider only the actual acres indicated for development over different time frames and different levels of development; they do not include loss or damage to acres surrounding the actual disturbance. They do not consider the problems of dislocation of the rancher or farmer; who has only part of his land disturbed by activities associated with mining, and the remainder of the unit is uneconomic and may, as a result, be out of production for a period of time.

At times, rules of thumb were used; such as, 3 acres per animal unit month grazing and an 8-month grazing season. There are certainly fluctuations within the area that would be quite different from some of the guidelines. There is no allowance in the analysis for increased production per unit of available land resource over time. Such increases could result in improved management from emergency research practices, including chemicals, flexible cropping patterns, genetic improvement, disease control, weather modification, and other production techniques. The analyses do not consider the loss of acres due to homesites, towns, and recreation developments that are likely to occur as a result of increased population in the area.

Discussion Draft
March 1974

ANALYSIS OF IMPACTS OF COAL DEVELOPMENT ON THE WILDERNESS-WILD LAND RESOURCE

I. INTRODUCTION

Because of time constraints, this analysis is based on the inventory as it is described in the profile section, even though there is an unknown amount of wild lands that will be affected by development. The alternatives for development (scenarios) are not complete nor do they reveal the total impact. Such information as other mineral development, transmission lines, water developments, railroads, roads, buildings, new towns, and population increases are not available for this analysis. These impacts will result in some unknown, unquantifiable impacts on the resource.

This analysis identifies some of the values that may be affected, and then subjectively arrives at the degree of impact on these values. This approach makes usable to the "decision-maker" those values that will be affected by development within this region. The analysis suggests an approach to further analyses to be utilized in planning the eventual outcome of developments in the Northern Great Plains.

II. BASIC ASSUMPTIONS

In considering the impacts on the wilderness-wild land resource, assumptions and considerations must be made, in addition to those general assumptions developed by the Surface Resources Work Group.

The wilderness-wild land resource will be affected adversely as a result of the following:

1. Development of the mineral resources will result in increased population and, therefore, increased use of the wilderness-wild land resource. Wilderness use is increasing at the rate of 15 percent per year.
2. Development of the mineral resources will result in off-mine site impacts from such other facilities as roads, railroads, transmission lines, aqueducts, reservoirs, housing developments, etc.
3. There will be increased efforts to create, develop, store, and regulate water, which will result in the modification of natural ecosystems and modification of negotiations because of the effect on aquifers.
4. The values of these lands will become more apparent as development progresses.
5. There will be a decrease in acres of wilderness and wild lands as development progresses.
6. There will be a greater impact to the wilderness-wild land resource than to acres disturbed. This will be a logarithmic progression rather than a linear progression.

III. OTHER CONSIDERATIONS

As a result of coal development and associated activities, conflicts will develop in land allocations. Social pressures may increase to preserve lands as preservation opportunities become more limited. As more people move and travel to this area, there will be some local economic benefits accruing from the utilization of those lands for recreation purposes. An improved land ethic on the part of people may even surface.

The water resource within this area is limited. Other regions with a similar condition have allocated the water resource to such an extent that natural vegetative conditions dependent on free-flowing streams have been severely modified. Without proper consideration of values involved, this condition may result in the Northern Great Plains.

The influx of people and their increased demands upon recreation opportunities of the wilderness-wild land resources may result in rules and regulations not necessary or commonplace today. Private landowners will likely take positive measures to post and effectively preclude persons seeking a wild land experience from lands now open to them. Regulations concerning use of public lands may become more stringent. This may result in limiting what many consider their individual rights today; e.g., posting of lands in Rosebud County, Montana, is now becoming commonplace.

IV. WILDERNESS-WILD LAND CHARACTERISTICS LIKELY TO BE AFFECTED BY COAL DEVELOPMENT

The social and cultural values placed upon these lands are difficult to assess. All characteristics will be affected to some extent as a result of development. The characteristics most likely to be affected are:

Solitude
Gene pool
Baseline for scientific evaluation
Undisturbed ecosystems
Diversity (cultural and physical)
Integrity
Development
Offsite intrusion
Quality and quantity of air
Quality and quantity of water
Mystery
Tranquility
Free-flowing water
Vastness
Availability
Experience
Carrying capacity
Quiet
Wildlife
Life style
Physical challenge
National heritage
Esthetic challenge
Intellectual challenge
Open space

The total value of the wilderness-wild land resource to society is difficult and, at this time, impossible to assess. It is a mixture of economic, cultural, and social considerations. The question of total assessment is not well understood, and is presently impossible to express in either economic or social terms.

V. ANALYSIS PROCEDURES

Matrices were developed to assist in identifying what impacts could be expected from mineral development within the region. While subjective, they indicate the relative effects on the wilderness-wild land values.

Wilderness and Primitive (existing and proposed)

1. This matrix considers impacts to existing and proposed classified lands which lie out-of-region, but are within the drainage area that serves the region.
2. The matrix shows the degree of regional impact, not the magnitude.
3. The values of these lands which will probably be affected are considered, and they include: opportunity for solitude, natural ecosystems, integrity, wildlife habitat, wildlife species, and water.
4. A single matrix analysis table was developed for the Beartooth and Cloud Peaks Primitive Areas and a composite matrix for the remaining proposed and classified areas outside the region.

Wild Lands

1. Where applicable, a matrix was developed for each sample county. Those matrices depicted only those impacts directly resulting from land disturbance due to mineral development.
2. A regional matrix was developed for the composite wild land resource. It showed the effects of proposed mineral development on a regional basis.
3. Wild land resource factors likely to be affected include: opportunities for solitude, natural ecosystems, wildlife habitat, wildlife species, water and air qualities, life style, and open space.
4. Areas likely to be directly affected by mining are depicted on the regional analysis matrix.

VI. DISCUSSION

Existing Areas Within the Natural Wilderness Preservation System

There will be no direct impact as a result of proposed coal mining operations on these areas. All effects are caused indirectly by increased use or possible water modifications or developments. Carrying capacities for these units have not been calculated. Research is currently underway that will assist managers to determine both the ecological and sociological carrying capacity of these areas.

Increased use will result in some loss of opportunities for solitude within these areas. Visitors seeking solitude may have to penetrate further or pick seasons when use is light. Some modification of natural ecosystems is expected because of increased use. Increased use may also result in modifying wildlife habitat and, to some degree, the number of species. Because these lands contribute water to the region, it is reasonable to expect a growing interest in weather modification projects, or other water developments that could result in despoiling this resource.

Proposed Units to the National Wilderness Preservation System

None of these units are directly affected by the projected mining operations. Any impacts will likely result from increased use or projects aimed at increasing or regulating the timeliness of water flows from these areas. Since these lands are in relatively close proximity to the area, they will probably receive more intensive use than those lands currently in the system. They may receive a greater degree of the same types of impacts as outlined in the previous discussion on units within the National Wilderness Preservation System.

Wild Lands

Oliver, Mercer, and Campbell Counties. There will likely be no direct impact on the inventoried wild lands (contained in the regional profile) as a result of projected coal mining operations within Mercer and Oliver Counties, North Dakota, or in Campbell County, Wyoming. This is not to say lands fitting the inventory criteria will not be affected, as the present inventory does not describe lands in the area of mineral development.

Rosebud County. Wild land area No. 47, administered by the USDA-Forest Service, will be affected by mineral development under the Base forecast in the year 2000. All factors of wilderness-wild lands considered will be adversely affected. Wild land area No. 6, administered by the Bureau of Indian Affairs, will be partially affected by mineral development under the Extensive forecast in the year 2000.

The remaining inventoried wild lands (those depicted in the regional profile will not be directly affected by mining operations. These will, however, experience some indirect effects which this analysis does not treat.

Bighorn County. Except for the years 1980 and 1985 Base forecast, there are varying degrees of impact which will occur during all time frames for all three forecasts. Mining operations during the year 2000 will have the greatest impact on wild land resources. Areas No. 15, administered by the Bureau of Indian Affairs, and No. 2, administered by the state of Wyoming, will be affected.

VII. SUMMARY

Actual mining operations will have little effect on the inventoried wilderness-wild land resource. A greater effect on this resource from related developments and increased population can be expected.

VIII. RECOMMENDATIONS

A system to evaluate total impacts of land allocations should be developed. The system should include such considerations as suitability, availability, and need. Considerations should include such items as:

1. Contributions to social demands.
2. The need to have representative areas to be used as benchmarks for scientific study.
3. Societies need to have available to them for spiritual rejuvenation.
4. The need for preservation of representatives of natural flora and fauna.

5. Contributions of wild lands to the quality of life.

6. Maintenance of a life style.

There are examples of lands, both in condition and kind, that exist within this region not currently included in the National Wilderness Preservation System. The characteristics of these lands are described in the regional profile section of this report. Examples include native grasslands, badlands, pothole regions, and other lesser known, unique features found in this region. Agencies of the Departments of Interior and Agriculture have the responsibility of seeking out and studying these lands for their suitability and availability for inclusion in the Wilderness Preservation System or some alternative administrative classification.

Discussion Draft
March 1974

IMPACT ANALYSIS OF COAL DEVELOPMENT ON SCENERY

I. INTRODUCTION

The regional profile for existing scenic values in the Northern Great Plains Resources Program area established the following subdivisions and distinct landforms:

1. Dakota-Minnesota Drift and Lakebed Flats.
2. North-Central Lake-Swamp-Moraine Plains.
3. Upper Missouri Basin Broken Lands.
    a. River Breaks (cottonwoods, grasses).
    b. Open Country, Flat (many draws, broadleaf trees, grasses, mixed agriculture and grazing).
    c. Badlands (River Breaks - Little Missouri and Powder Rivers).
    d. Open Country, Rolling (sagebrush, grasses, mixed plant species).
    e. Missouri Slope (short grasses, grazing).
    f. Scattered Ponderosa Pine Country (mountains, open valleys, varied uplands, scenic).
4. Black Hills (including Devils Tower country).
5. Middle Rocky Mountains (Big Horn Mountains).
6. Lower Rocky Mountains (Laramie range).
7. Wyoming - Big Horn Basin

The analysis of the impacts of the three coal development forecasts upon the scenery is limited to four sample locations within the NGPRP study area. These locations are the counties of Big Horn and Rosebud in Montana, Mercer and Oliver in North Dakota, and Campbell in Wyoming.

This impact analysis is necessarily subjective, as was development of the scenery regional profile. However, preparation of the regional profile indicated that recognition of visual elements contributing or detracting to the pleasure of the viewer were common to most observers.

The most critical deficiency in the analysis is the lack of field reviews because of the short study period, combined with inclement seasonal conditions. Accordingly, conclusions are based upon the broad scope of the scenery regional profile, reviews by persons knowledgeable of the sample areas, and study of U.S. Geological Survey maps at 1:250,000 scale and Earth Resources Technical Survey imagery at 1:1,000,000 and 1:500,000 scales. A second deficiency is the impact upon scenic qualities in the rating system, whereby the degree and magnitude of impact reflect only a particular area as compared to the scenic qualities of that entire sample area. For example, in the two-county, Mercer-Oliver, area the impact of surface mining was considered to have a serious adverse effect (both in degree and magnitude) for the Knife River Valley. On the other hand, this impact may be less severe scenery-wise than a similar development in the Colstrip, Rosebud County, Montana area, which has what is considered higher scenic qualities, but where the degree and magnitude of impact may be less. The foregoing illustration was borne out in the matrix analysis of impacts of coal development forecasts.

Further studies should eliminate or ameliorate these deficiencies when specific sites and development are known, adequate field studies undertaken, and all existing developments are reviewed.

II. ADDITIONAL ASSUMPTIONS

In preparing this analysis, the basic assumptions applicable to the Surface Resources Work Group were supplemented with the following additional special considerations:

1. The scenic qualities will not equal existing qualities for a minimum of 25 years. This is based upon a natural healing by weathering, erosion, etc. of development scars on the earth's surface and time required for vegetal growth to equal predevelopment conditions.
2. Enhancement of scenery on some reclaimed lands may occur, such as the development of an eye-pleasing body of water which cannot be quantified at this time.

III. FACTORS RECOGNIZED IN ASSESSING IMPACTS UPON SCENERY

Of the following factors, 1 and 2 relate to intrusions on scenery arising from construction and operation of energy developments; whereas 3 and 4 result from the alteration of the scenery.

1. Land, water, and air affected by the three coal development forecasts for 1980, 1985, and 2000. Examples of these factors would be disturbance of the surface by strip mining, depletion of water resources where they add to the scenic qualities, and visible stack emissions from coal-fired powerplants and coal conversion plants.
2. Associated support facilities having an impact upon scenery include towns, highways, service roads, airports, railroads, and transmission lines.
3. Animal life--both domestic and wild--, whose presence adds scenic interest.
4. The impact upon the total view which may be confined to a closed valley or be in the visual range of a distant view.

IV. ANALYSIS DEFINITIONS AND EXPLANATIONS

1. Affected Factors. Physical subdivisions, categories, and features are derived from the scenery regional profile, and are shown in the Northern Great Plains Resources Program regional profile, Appendix E, Plate 6 at 1:1,000,000 scale. Numbers refer to those shown on that map. These categories include the following physical subdivisions and categories:

3--Upper Missouri Basin Broken Lands, a-River Breaks, b-Flat Open Country, d-Rolling Open Country, and e-Missouri Slope; and 5--Middle Rocky Mountains - Big Horn and Pryor Mountains.

2. Magnitude. Represents the percent of the individual sample area experiencing the primary impact. Low percentages existing in the early years reflect the impact of strip mining activity; i.e., the disturbed surface area and the associated support facilities. In later years, the establishment of coal-fired powerplants and coal conversion plants greatly enlarges the immediate impact area through visual stack emissions and possible loss of streamflows. No affected acreages could be shown, since scenery is not confined to specific land measurements.

3. Degree. Numerically indicates the severity of the impact. Existing condition = 0; most severe condition = -9. Since the first study year of the coal development forecast is 1980 and the last year is 2000, the basic assumption for scenic rehabilitation is 25 years; therefore, there are no positive degrees.

V. RESULTS

Sample Area, Big Horn County, Montana

The scenic values considered consisted of Upper Missouri Basin Broken Lands (3) with the category of Scattered Ponderosa Pine Country; (3f) the Middle Rocky Mountains; and (5) containing the

Big Horn and Pryor Mountains. As determined by the analysis, the development of power and conversion plants would have the greatest impact on scenic views.

All of the impacts will result from smoke plumes from power generation plants and gasification plants. There is no strip mining planned in the Pryors, the Big Horns, or the Scattered Ponderosa Pine Country near Hardin, Montana. Because the plant locations will all be to the east of Hardin and because the prevailing winds are westerly, it was extremely difficult to judge visual air pollution impacts. Our opinion is that actual plumes on the horizon will be the only impact for most parts of these areas; that is why the degree of impact is so low. As more plants come into operation, as in the extensive forecast, it is obvious that plumes will be visible over more of the region. Because of the prevailing winds, we estimated that a general haze probably will form over much of the Northern Great Plains Resources Program area, and will be mostly to the east of these three areas.

Sample Area, Rosebud County, Montana

The Upper Missouri Basin Broken Lands (3) is the only physical subdivision in this area consisting of the following categories: River Breaks (3a), Flat Open Country (3b), and Scattered Ponderosa Pine Country (3f).

Because of the different locations in relation to mine sites, power plants, and gasification plants, the degree of impacts varies significantly among the four sample areas. By year 2000, in the most probable forecast and throughout the extensive forecast, the Yellowstone River Breaks (3a) will be impacted by gasification and generation plant operations. For the most part, this impact will be smoke--which almost certainly will develop into a general haze by 2000 under the extensive forecast. A major road upgrading effort in the Colstrip area will likewise cause an adverse impact.

The second area, Open Country north of the Yellowstone (3b) will sustain very little scenic impact from the proposed development, as far as can be determined. Smoke plumes will be visible over most of the southern part of the area. In addition, some haze is likely to occur.

The third area is 3f, Scattered Ponderosa Pine and open parks south of the Yellowstone. This subgroup concludes that it is by far the area of most serious direct conflict between coal, gas, and power production and scenic values that occurs anywhere in the NGPRP study area. In the early years, a small part of the area will be impacted, but to a high degree. That is the result from actual mining operations. With the advent of power and gasification plants, a much greater part of the region will notice the effects of development because of smoke in the air. However, because the impact will be limited to the air in most of the impacted area, the degree of impact will decline. There is no doubt that coal development will cause major damage to the scenic values of this part of the Northern Great Plains.

A fourth category was evaluated to show the pattern of impact upon a typical scenic feature. Castle Rock (3f) near Colstrip is considered part of the preceding paragraph's discussion. It can readily be seen that little scenic damage will occur to this feature during the mining operations. Air pollution is, again, the critical factor in scenery consideration.

Sample Area, Mercer-Oliver Counties, North Dakota

The Upper Missouri Basin Broken Lands (3) include the categories of River Breaks (3a) and the Missouri Slope (3e). The degree of impact from Forecasts I and II primarily relates to the open pits and stack visibility. This results in a small area being impacted--but to a severe degree. Under Forecast III, the increased number of plants with stacks will greatly add to the visual air emission problem. Because of this probability, a much greater area will be impacted, resulting in a greater magnitude of adverse effects.

The problem in Mercer and Oliver Counties is very severe, partly because of the intensity of development in the two counties, but also from the major plants across the Missouri River from Stanton. The coal in this part of the Northern Plains is very low grade, and the likely infeasibility of hauling the coal to distant plants makes it probable that these counties will experience the brunt of a full-range coal industry. As was the case in previous discussions, the early stages are usually mining activities which affect only a small physical area. When smoke-producing plants are put into operation, a major air pollution problem can be expected. The Knife River Valley and the uplands throughout the counties will be impacted more than the Missouri River Valley and adjoining bluffs and draws. Fortunately, scenery in this part of North Dakota is of less quality than most other areas in the State and westward. This fact is not revealed by the matrix analysis, which represents a major deficiency--no provision for rating scenic values.

Sample Area, Campbell County, Wyoming

This area is within the Upper Missouri Basin Broken Land subdivision (3), and includes the categories of River Breaks (3a) and Rolling Open Country (3d).

As is usually the case in the other sample areas, we do not believe mining operations by themselves provide a major scenic problem to Campbell County. The mine sites, roads, and other supporting developments will be noticeable over only small areas. However, because of the prairie setting--with clear air and long vistas--practically any material put into the air is visible over wide areas. Even dust devils can be seen for miles. As a result, the analysis for Campbell County reflects the power and gasification plant development by fairly low impacts over wide areas. The specific impact will be on visual air quality.

Analysis of Regional Impacts of Three Coal Development Forecasts over Three Time Frames

It was determined that this analysis could not properly be applied to scenery. In most instances, the regional impacts would be similar to those provided by the sample area. In other areas, such as Mercer-Oliver Counties, a considerable amount of visual air and surface impacts would emanate from developments outside the sample area on the east side of the Missouri River, resulting in an additional immediate area impact but would not measurably change the regional impact.

There is also the problem of attempting to compare qualities among entirely different types of scenery. While the scattered pines on the hills around Colstrip, Rosebud County, Montana may possess more of the recognized attributes of scenery, the Knife River Valley also has its own kind of scenic values.

These regional qualities, unfortunately, cannot be indicated in the analysis since it is concerned only with the estimated impact on scenic values.

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March 1974

IMPACTS OF COAL MINING ON COMMERCIAL FOREST LAND AND SUSTAINED FLOW OF TIMBER PRODUCTS OUTPUT

I. INTRODUCTION

Commercial forest land is defined as land suitable and available for the production of crops of industrial wood at a rate of at least 20 cubic feet per acre per year, under management. Obviously, if surface mining of coal is done on such land, the tree cover is removed and the area of commercial forest land is reduced. After mining, however, new stands of timber can be established through rehabilitation of mined land.

II. ADDITIONAL BASIC ASSUMPTIONS

1. Any forest land mined is commercial forest land, suitable and available for timber production.
2. Before mining commercial forest land, the timber crop on the land will be harvested.
3. The commercial forest land area supports the growing stock and board foot per acre volumes estimated, and each acre supports the same volume. Per acre volume estimates are simply cubic foot or board foot growing stock volumes divided by the number of acres of commercial forest land.
4. Timber products output can and will come from any commercial forest land in a country. In other words, lost output from acre A can be replaced by output from previously unused acre B.

III. RESULTS

Of the four sample areas, only three (Big Horn, Oliver-Mercer, and Rosebud Counties) have commercial forest land. Moreover, only a small part of the productive potential of this commercial forest land is currently being utilized--even when using the low production potential estimate of 20 cubic feet per acre per year (see Table 1).

The impacts of all projected mining activities in the study area on both commercial forest land and sustained timber products output would have to be considered as relatively insignificant. First, because of the small proportion of the area involved, and, secondly, because of the very low current level of use of the wood resource compared with the potential use.

Table 1.--Potential productivity of commercial forest land, thousand cubic feet

Sample area	Factor for estimating potential productivity per acre	Commercial forest land	Estimated total potential productivity	Output of roundwood products 1969-1970
County	Cu.ft.	M acres	M cu.ft.	M cu.ft.
Big Horn	20	199	3,980	0
Campbell	20	0	0	0
Oliver-Mercer	20	5	100	0
Rosebud	20	177	3,540	265

Only two sample areas (Big Horn and Rosebud Counties, Montana) will lose acreages of commercial forest land from mining activities. According to the assumptions made, the area of commercial forest land lost will be 10 and 15 percent of the mined area in Big Horn and Rosebud Counties, respectively. This amounts to less than 5,000 acres--even at the most extensive mining forecast--, and represents only about 1 percent of the commercial forest land involved.

At the present time, the timber resource could absorb considerably more demand for wood products associated with uses attendant to increased mining activity and economic development in the study area. Sustainable output could probably be increased with more intensive management of the timber resource, even in the face of reduced commercial forest land area. However, rehabilitation work would minimize the annual loss of timber-growing base, thus probably not requiring expenditures for intensified management for some time.

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March 1974

IMPACTS OF COAL DEVELOPMENT ON SURFACE REHABILITATION

I. INTRODUCTION

The regional profile report was concerned with descriptions of the soil associations, vegetation types, and precipitation characteristics that combine to delineate different rehabilitation response units on the surface minable lands of the Northern Great Plains. This report constitutes a summary of analyses indicating the various degrees of potential success that might be expected in attempting to reclaim and revegetate the different rehabilitation response units of the Northern Great Plains.

II. PROCEDURES

Rating Criteria for Ranking Rehabilitation Response Units According to their Rehabilitation Potentials

The relative ranking of rehabilitation response units according to their rehabilitation potentials depends upon the combined ratings of soil productivity and stability, vegetation suitability and availability for rehabilitation, and the amount and distribution of annual precipitation. Each of these soil, vegetation, and precipitation characteristics was rated on a descriptive-numerical scale as follows: very good--(+9), good--(+6), fairly good--(+3), fair--(0), fairly poor--(-3), poor--(-6), and very poor--(-9).

Soil Association Productivity and Stability Rankings. The productivity for vegetation and the stability against surface erosion of each of the 17 surface minable soil associations in the Northern Great Plains was rated, using the above descriptive-numerical scale. Information concerning the productivity and stability of the soil associations was obtained from Aandahl's description of soil associations of the Northern Great Plains. These ratings are shown in Table 1. Also presented in Table 1 is a combined rating for each soil association, obtained by averaging productivity and stability ratings. These combined ratings show that soil associations 19 and 25, each with a rating of +8, are

Table 1.--Relative ranking of soil associations in terms of productivity and stability

Soil association number	Productivity rating	Stability rating	Combined rating
19	+6	+9	+8
23	+6	+6	+6
25	+9	+6	+8
26	+6	+6	+6
27	+3	+3	+3
30	+3	+3	+3
31	0	-6	-3
33	0	-6	-3
34	0	-6	-3
35	0	-9	-5
44	-3	-3	-3
109	-9	0	-5
111	-6	-3	-5
117	-6	0	-3
121	-9	-9	-9
123	-9	-6	-8
184	-9	-9	-9

the most productive and stable of the 17 soil associations. Combined ratings also show that soil association 123 (with a rating of -8) and soil associations 121 and 184 (each with a rating of -9) are the least productive and most erodible of the 17 soil associations.

Vegetation Type Suitability and Availability Ratings. The suitability of the major native plant species in each of the nine surface minable vegetation types, and their availability for rehabilitation purposes, were rated, using the descriptive-numerical rating scale. These two ratings were averaged to provide a single combined suitability-availability rating of major species for rehabilitation in each of these vegetation types. These ratings are presented in Table 2. They show that the mid-tallgrass prairie has the most suitable and available plant species for successful rehabilitation. They also show that the

Table 2.--Relative ranking of vegetation types in terms of suitability and availability of plant species for rehabilitation

Vegetation type	Type number	Suitability rating	Availability rating	Combined rating
Flood plain	1	-6	-3	-5
Badlands	2	-9	-9	-9
Shortgrass prairie	3	-3	0	-2
Mid-shortgrass prairie	4	-3	0	-2
Midgrass prairie	5	0	+6	+3
Grassland-sagebrush	6	+6	+3	+5
Sagebrush steppe	7	+3	-3	0
Mid-tallgrass prairie	9	+9	+9	+9
Ponderosa pine forest	12	0	+6	+3

Badlands offer the poorest chance for rehabilitation, but that--with the exception of the Badlands--all of the vegetation types contain some plant species that are suitable and available for rehabilitation purposes.

Precipitation Amount and Seasonal Distribution Ratings. The amount and seasonal distribution of annual precipitation on the surface minable lands of the Northern Great Plains were rated, using the descriptive-numerical ratings. These two ratings were averaged to provide a combined precipitation rating. These ratings are presented in Table 3; and, as might be expected, they show that the areas with more than 16 inches of annual precipitation have the best potentials for rehabilitation, while those with less than 12 inches have the poorest potentials.

Table 3.--Relative ranking of precipitation zones in terms of annual amounts and seasonal distribution

Precipitation zone	Amount rating	Distribution rating	Combined rating
<12	-9	-9	-9
12	-6	-6	-6
13	-3	-3	-3
14	0	0	0
15	+3	+3	+3
16	+6	+6	+6
>16	+9	+9	+9

III. RESULTS AND DISCUSSION

Rehabilitation Potential Rankings of Rehabilitation Response Units

In order to translate the combined ratings of soil, vegetation, and precipitation characteristics into one rehabilitation potential rating for each of the various kinds of rehabilitation response units on surface minable lands in the Northern Great Plains, the combined rating values of the appropriate soil association (Table 1), vegetation type (Table 2), and precipitation zone (Table 3), comprising each rehabilitation response unit were added together algebraically and averaged. This provided a rating number for each rehabilitation response unit having a potential range from +9 to -9. These rating numbers indicate the relative degree of ease or difficulty (potential) that should be anticipated in attempting to rehabilitate a given unit area of surface mined land having given soil, native vegetation, and precipitation characteristics. These matrix degree values range from +6 to -5, indicating that none of the rehabilitation response units exhibit either the best or the worst potential for rehabilitation.

The total area of each different kind of rehabilitation response unit in each state and county of the Northern Great Plains study area is shown in Table 5 of the regional profile report. The areas of each of these different kinds of rehabilitation response units that will be mined in each of the designated four sample areas and in the remainder of the study region are shown as "magnitude" values (expressed as acres) in the matrices. The "degree" ranking and the "magnitude" area of each rehabilitation response unit were multiplied together for each of the three time frames within each of the three coal forecasts. Essentially, this means that the "degree" rankings, which indicate the relative potential for rehabilitating a unit area of a given rehabilitation response unit, have been weighted by the "magnitude" (acres) which it will be necessary to mine in order to meet the coal production requirements of each forecast--time-frame sequence. The algebraic totals of these "degree-magnitude" products are summarized in Table 4. For purposes of comparison, the "magnitude" values (surface mined areas) alone are summarized in Table 5. Finally, the weighted "degree" ratings, summarized in Table 4, were divided by the "magnitude" values in Table 5 to provide the average weighted rehabilitation potential ratings by sample counties and by the remaining regional area for each coal development forecast and each time frame. These average weighted rehabilitation potential ratings are summarized in Table 6.

Table 4.--Rehabilitation potential ratings weighted by areas that will be surface mined under each of three coal development forecasts and three time frames 1/

Development forecast	By the year	Campbell county	Big Horn county	Rosebud county	Mercer-Oliver Counties	Other regional	NGPRP area
Base	1980	+48	+192	+1086	+5483	0	+6809
	1985	-2712	+1252	+2781	+10663	+4155	+16139
	2000	-10991	+4432	+7866	+26203	+17820	+45330
Most probable	1980	+48	+192	+1086	+5483	0	+6809
	1985	-2712	+2280	+2781	+10663	+4155	+17167
	2000	-18881	+14355	+19491	+36808	+64230	+116003
Extended	1980	+48	+192	+1086	+5483	0	+6809
	1985	-2409	+3200	+4176	+31873	+34375	+71215
	2000	-28283	+25400	+52506	+121148	+207385	+378156

1/ Degree ratings X area mined.

Table 5.--Surface mined areas that will require rehabilitation under each of three coal development forecasts and three time frames

Development forecast	By the year	Campbell County	Big Horn County	Rosebud County	Mercer-Oliver Counties	Other regional	NGPRP area
		Acres	Acres	Acres	Acres	Acres	Acres
Base	1980	56	96	1,605	2,599	0	4,356
	1985	2,036	1,276	4,900	5,999	900	15,111
	2000	7,977	4,816	14,785	16,199	3,840	47,617
Most probable	1980	56	96	1,605	2,599	0	4,356
	1985	2,341	1,533	4,900	5,999	900	15,673
	2000	12,287	9,018	22,690	26,804	18,330	89,129
Extended	1980	56	96	1,605	2,599	0	4,356
	1985	2,341	1,993	6,295	13,069	8,870	32,568
	2000	25,890	13,528	43,975	54,584	57,110	195,087

Table 6.--Average weighted rehabilitation potential ratings for each of three coal development forecasts and three time frames

Development forecast	By the year	Campbell County	Big Horn County	Rosebud County	Mercer-Oliver Counties	Other regional	NGPRP area
Base	1980	+0.86	+2.00	+0.68	+2.11	--	+1.56
	1985	-1.33	+0.98	+0.57	+1.78	+4.62	+1.07
	2000	-1.38	+0.92	+0.53	+1.62	+4.64	+0.95
Most probable	1980	+0.86	+2.00	+0.68	+2.11	--	+1.56
	1985	-1.16	+1.49	+0.57	+1.78	+4.62	+1.10
	2000	-1.54	+1.59	+0.86	+1.37	+3.50	+1.30
Extended	1980	+0.86	+2.00	+0.68	+2.11	--	+1.56
	1985	-1.03	+1.61	+0.66	+2.44	+3.88	+2.19
	2000	-1.09	+1.88	+1.19	+2.22	+3.63	+1.94

Implications of Rehabilitation Response Unit Rankings for Rehabilitation of Surface Mines in the Sample Counties and Other Areas of the Northern Great Plains

Inspection of the rehabilitation potential ratings, weighted by areas that will be surface mined (Table 4), reveals that--of the four sample areas --the rehabilitation response units that characterize Mercer and Oliver Counties in North Dakota collectively have a much higher potential for successful rehabilitation than do the rehabilitation response units in any of the other three sample counties. This is probably due to more productive soils, more suitable vegetation types, and higher precipitation in Mercer and Oliver Counties than in the other three sample counties. The weighted rehabilitation potential ratings in Table 4 also show that Rosebud County, Montana has the next best potential for successful rehabilitation, followed by Big Horn County, Montana, and Campbell County, Wyoming. The poorest rehabilitation potential, in Campbell County, Wyoming, results from a combination of poorly productive soils, vegetation types having fewer suitable and available species, and the lowest precipitation in the Northern Great Plains resources study area. The remainder of the Northern Great Plains resources study area, outside of the four sample areas and designated "other regional" in Tables 4, 5, and 6, exhibits rehabilitation potential ratings (Table 4) nearly as good, and, in some cases better than, those of Mercer and Oliver Counties.

As might be expected, the rehabilitation potential ratings (Table 4) become larger in either a positive or negative direction as the coal development forecast shifts from "base" to "most probable" to "extended." An exception to this occurs up to the year 1980 because the kinds of rehabilitation response units and the areas thereof to be mined in that time frame are the same for all three development forecasts.

Table 5 reveals that the surface mined areas requiring rehabilitation will increase as the coal development shifts from base to most probable to extended, and as the time frame moves from year 1980 to 1985 to 2000. These increases in acreages to be mined imply, in themselves, an increasingly larger rehabilitation job regardless of location.

The average weighted rehabilitation potential ratings (values in Table 4 divided by values in Table 5 and also obtainable by averaging the appropriate "degree" values in the matrices) are presented in Table 6. These values reveal information similar to that in Table 4, with the exception that the masking effect due to differences in the areas to be mined has been removed. The values in Table 6 reveal several kinds of important information as follows:

1. Taking the Northern Great Plains resources study area as a whole, the average potential for successfully rehabilitating surface mined lands increases with a shift from base to most probable to extended coal development forecasts. Essentially, this means that as the intensity of surface mining increases in the Northern Great Plains, progressively more mining will be done on rehabilitation response units having high

rehabilitation potential ratings then

will be done on those having low ones. This is especially true in all of the four sample areas. In the remainder of the region, the average weighted rehabilitation potential ratings decrease with intensification of mining activity, indicating that if intensified coal mining development takes place in these other regional areas, progressively more of the rehabilitation response units having low potentials for rehabilitation will be mined than will those having high potentials. Nevertheless, the average potentials for rehabilitation in these other regional areas--even with intensified coal development--are higher than in any of the sample county areas.

2. The highest average weighted rehabilitation potential ratings occur on other regional areas outside of the four sample areas. The Mercer and Oliver County areas have the highest ratings of the four sample counties, followed in decreasing order by Big Horn, Rosebud, and Campbell Counties. The lowest rehabilitation potential ratings, which, in fact, average out to be negative values, occur in Campbell County.

3. Within the base development forecast, each of the sample counties exhibits a decrease in average rehabilitation potential ratings as the time frame shifts from the year 1980 to 1985 to 2000. In other words, the moderate increase in mining intensity associated with the changing time frame in base development forecast will result in the mining of a higher proportion of rehabilitation response units having low rehabilitation

potentials than those having high ones. Outside of the sample counties, virtually no mining development is scheduled prior to 1980, and the average rehabilitation potential ratings are virtually the same in the years 1985 and 2000.

4. Within the most probable development forecast, a decrease in the average rehabilitation potential ratings of each of the sample counties occurs between 1980 and 1985. This is, essentially, a very similar decrease to that occurring over the same time frame in the base development forecast. Between the years 1985 and 2000, however, a further continued decrease in the average rehabilitation potential ratings occurs only in Campbell County, Mercer and Oliver Counties, and the other regional areas. In Big Horn and Rosebud Counties, the average rehabilitation potential ratings will increase from 1985 to 2000. This indicates that between 1985 and 2000 currently planned scheduling of mining activities in these two counties in the most probable development forecast includes more rehabilitation response units having high rehabilitation potentials than those having low ones.
5. Within the extended development forecast, the average rehabilitation potential rating for Campbell County decreased throughout the three time frames. In Big Horn and Rosebud Counties, the rehabilitation potential rating decreased from 1980 to 1985, but then increased again between 1985 and 2000. On the other hand, the rehabilitation ratings for Mercer and Oliver Counties

increased from 1980 to 1985, but then decreased between 1985 and 2000. The rehabilitation potential ratings for the other regional areas, although the highest in the entire study area, still decreased between 1985 and 2000. These increases and decreases in rehabilitation potential ratings reflect the differences in relative ease or difficulty of rehabilitating surface mined lands as a result of the sequential order in which rehabilitation response units having better than average and poorer than average potentials for rehabilitation are scheduled for mining. Such comparisons as have been made here, if carried back into the individual matrix components (the individual rehabilitation response units and their "degree" ratings), could be utilized to restructure the development forecasts with respect to the location of future mines in relation to the various rehabilitation response units overlying surface minable coal. Such restructuring could establish a more uniform distribution of rehabilitation potentials with respect to time; and, hence, a more uniform rehabilitation effort required throughout any coal development period for any given portion of the Northern Great Plains.

Comparison of Rehabilitation Potential Ratings from Actual Rehabilitation Efforts and from "Degree" Ratings of Rehabilitation Response Units as Developed in the Matrices

Table 5 of the regional profile report lists 15 coal and 3 bentonite mines for which rather firm descriptive information exists concerning the relative success of past rehabilitation efforts. Accordingly, it was considered desirable to compare the descriptive ratings of rehabilitation success on these mines with the ratings of the rehabilitation response units in which these mines are located and which are expressed numerically as the "degree" item in the matrices. These comparisons are presented in Table 7. The numerical equivalents of the descriptive ratings of actual rehabilitation success on these mines, when compared with the "degree" ratings of rehabilitation response units as they appear in the matrices, reveal that the matrix ratings of degree of potential rehabilitation ease or difficulty on these mines are probably somewhat conservative. They indicate a rehabilitation potential rating slightly less than the rating of actual rehabilitation success achieved on these mines. Notwithstanding, this sample of only 18 mines, some of which have enjoyed only a short period of rehabilitation effort, is sufficiently small that alteration of the matrix "degree" ratings to conform to the actual rehabilitation success ratings is not yet warranted. Furthermore, the predictive ratings are, with few exceptions, sufficiently close to the actual ratings that they can be used conservatively with confidence.

Table 7.--Comparison of rehabilitation potential ratings from actual rehabilitation efforts and from "degree" ratings of rehabilitation response units

Kind of mine	Mine no.	Name of mine	Rehabilitation response unit	Rehabilitation potential ratings: From actual rehabilitation: Descriptive	Rehabilitation potential ratings: From actual rehabilitation: Numerical	Rehabilitation potential ratings: From "degree" ratings: Numerical
Coal	1	Wyodak Resources	117-6-14	Good	+6	+1
Coal	2	Amax Belle Ayr	117-6-13	Fairly good	+3	0
Coal	5	Big Horn	25-6-15	Good	+6	+5
Coal	11	Decker	117-6-15	Fairly good	+3	+2
Coal	12	Sarpy Creek	31-4-14	Fairly good	-3	-2
Coal	13	Peabody	31-12-16	Fairly good	+3	+2
Coal	14	Western Energy	31-12-16	Fairly good	+3	+2
Coal	15	Knife River (Savage)	26-5-13	Good	+6	+2
Coal	20	Baukol-Noonan (Center)	35-5-16	Fairly good	+3	+1
Coal	21	North American	35-5-16	Fairly good	+3	+1
Coal	22	Knife River (Beulah)	23-5-16	Good	+6	+5
Coal	23	Consolidation (Stanton)	35-5-16	Fairly good	+3	+1
Coal	24	Baukol-Noonan (Noonan)	19-9-15	Very good	+9	+7
Coal	25	Consolidation (Velva)	19-9-16	Very good	+9	+8
Coal	26	Knife River (Gascoyne)	25-5-15	Good	+6	+5
Bentonite	29	International Minerals	111-5-14	Fair	0	-1
Bentonite	30	American Barroid	111-5-14	Fair	0	-1
Bentonite	31	Federal Minerals	111-5-14	Fair	0	-1

1/ Tables 1, 2, and 3.

IV. CONSTRAINTS AND LIMITATIONS ON REVEGETATION

Very little experimentation and research have been directed to the problem of rehabilitating lands of the Northern Great Plains that are being mined for coal. While we have considerable knowledge about revegetating western lands, and reason suggests that this knowledge should be extendible to mine spoils, actual rehabilitation efforts on mine spoils to support this belief have been applied at only a relatively few mine sites. Perhaps the most important single point emerging from this study of surface rehabilitation potentials is that, against the background of current knowledge, one must almost inevitably conclude that the potential for rehabilitating surface mined land in the Northern Great Plains is extremely site specific. While we can judge the general rehabilitation potential on the basis of climatic, soil, and vegetative site components, each site will also have its particular microclimate in terms of specific physiographic, biotic, and hydrologic components. All of these components influence the potential for rehabilitation of a specific site. Finally, what we do to prepare a site for rehabilitation and how we do it, consists of a number of components that also influence the rehabilitation potential. These macro- and micro-site components, as well as the measures employed to effect rehabilitation, inherently impose constraints and limitations on the rehabilitation of some sites. Following is a brief summary of constraints on and limitations to successful rehabilitation of surface mined sites in the Northern Great Plains:

1. Macro-climate: Local climate is, without question, the most important single parameter in assessing potential rehabilitation success. Furthermore, the most important single climatic element influencing this success is the amount and distribution of precipitation. Assuming that approximately 10 inches of annual precipitation is the minimum amount of water needed to sustain revegetation, most surface mined sites receiving only 10 inches or less annual precipitation cannot be mapped accurately because adequate precipitation records are lacking for most existing and proposed mined sites, and the nearest weather station may be many miles removed.

   Variation of the annual precipitation about the mean is extremely important to revegetation success. Droughts severe enough to almost wreck the range livestock industry in the Northern Great Plains have occurred--and will, no doubt, occur again. Potentials for successful rehabilitation during such droughts would be far less than those during average or above-average years of precipitation. Little site specific analytical work has been done on precipitation variation in the Northern Great Plains.

2. Micro-climate: Most of the surface minable lands in the Northern Great Plains are characterized by relatively gentle topography. In many instances, the spoil piles left after mining constitute rougher topography than existed before mining.

The configurations into which these spoil piles are shaped by grading with heavy machinery can have substantial influence on the micro-climate of each surface mined site. The steepness of slope, the roughness of surface, and the direction of aspect with respect to solar insolation can all be affected by the land reshaping plans and measures employed.

3. Availability of suitable plant materials: One of the basic assumptions of this study is that unless some other rehabilitation objective is defined, the primary objective of rehabilitation on surface mined lands in the Northern Great Plains is to establish a protective cover of durable plants, predominantly the native species that were already adapted to and characterized these areas before mining. Accordingly, tall-, mid-, and short-prairie grass species, together with some shrubs and a few trees, are the plant materials that will be involved chiefly in rehabilitation of these surface mined lands. The surface minable lands in the North Dakota portion of the study area are characterized by a rich mixture of tall- and mid-prairie grass species, the seeds of which are usually available commercially in quantity. The drier portions of the study area, which are in northeastern Wyoming and eastern Montana, are characterized by short-grass prairie species which occur in some places in a mixture with dryland shrubs. These species are not nearly as available commercially as are the tall- and mid-grass species in the moister parts of the study area. A

supply of seeds from these dryland species needs to be developed if they are to be available in sufficient quantities for rehabilitation of the lands to be surface mined.

4. Site and seedbed preparation: More than a half century of range revegetation and farming experience in the Northern Great Plains has resulted in development of site and seedbed preparation techniques that can be utilized successfully in revegetating disturbed landscapes. Minimum requirements would certainly include grading of spoils to short lengths of gentle-to-moderate slopes and placement of the highest site productive overburden strata on the surface. Equally essential is the tillage (through established agricultural procedures) of spoil surface materials to a satisfactory condition for seeding and planting. Failure to shape and till the land satisfactorily will ordinarily result in greatly reduced rehabilitation success, or even in complete failure.

5. Planting procedures: Use of suitable planting procedures that provide for seed coverage by surface spoil materials at the proper depths is essential for successful revegetation of surface mined land. Seeds cannot be simply thrown upon bare ground without the application of planting technology. Many years of range revegetation and farming experience in the Northern Great Plains have identified the crucial elements of planting procedures necessary for successful reestablishment of vegetation. Among these elements are the best methods for

seeding and planting, the best methods and depths for covering different kinds of planted seeds, the best season to plant for each geographical locality, and the best kinds of mulch and its application to increase seed germination and seedling survival. Failure to apply all steps of the best planting procedures carefully can only result in reduced revegetation success.

6. Fertilizers and soil amendments: As indicated earlier in this report, it has been generally concluded that the lands in Wyoming and Montana that characterize the western portion of the Northern Great Plains coal province are deficient in phosphorus. Similarly, the lands that characterize the eastern portion, predominantly in North Dakota, exhibit nitrogen deficiencies. Despite these generalities, information concerning the fertility regime of the surface several feet of mine spoils destined for revegetation needs to be obtained. Fertilizers that meet the nutrient deficiencies in these spoils need to be assembled and applied to obtain the best revegetation success.

Spoil bank materials in the Northern Great Plains are nearly always alkaline. Most of these spoil materials have a high saturation percentage value. These high values are due to high clay content and cation composition, and result in many subsoils exposed by strip mining being relatively high in salinity. This situation can often be corrected, such as by adding gypsum, provided that sufficient planning and effort have gone into the operation to know where the surface spoils are saline and the magnitude of salinity involved. It goes without saying that every effort should be made to bury soils having toxic saline levels.

7. Irrigation: Erratic climatic conditions in the Northern Great Plains, especially in the amounts and distribution of precipitation, still remain the predominant factor that determines success or failure of revegetation efforts on surface mined sites carved out of semiarid rangeland ecosystems. Accordingly, addition of irrigation water--especially during growing season droughts--is sometimes desirable and even necessary to aid the establishment and survival of seedlings. Many of the subsurface and some of the surface water supplies in the Northern Great Plains have high sodium contents. Accordingly, irrigation of newly planted mine spoils must be done carefully and, frequently, in association with the use of soil amendments, to avoid the development of saline conditions in the spoils that are unfavorably high for survival and development of vegetation.

8. Spoil surface stabilization: As indicated previously in this report, some of the spoil materials encountered in the Northern Great Plains are fairly resistant to erosion by water and wind, while others are not. In general, the most highly erodible spoils (because they usually contain more sodium on

the clays) occur in the North Dakota portion of the Northern Great Plains. This area also receives the most rainfall. Generally speaking, these two circumstances combine to produce the most overland flow and surface soil erosion on North Dakota mine spoils. Under such conditions, it is desirable--and probably even necessary--to prevent or control such surface instability if vegetation is to be established on these sites. Prevention or reduction of surface runoff and soil erosion from mine spoils can be achieved by a combination of measures, including grading to gentle slopes, terracing, pitting, and mulching. Failure to stabilize spoil surfaces against raindrop and runoff impacts prior to the establishment of vegetation usually results in a high degree of rehabilitation failure.

9. Post-rehabilitation care: Rehabilitation of such drastically disturbed sites as surface mine spoils is somewhat similar to planting and landscaping the yard of one's newly built home. It would be unthinkable to carefully plant a lawn, shrubs, trees, and flowerbeds and then walk off and leave it to get along as best it can without any subsequent care. Similarly, it should also be equally unthinkable to carefully do everything necessary to insure successful rehabilitation of mine spoils, but then turn right around and forfeit the entire effort for lack of some necessary subsequent care. In other words, the land must be managed during and after rehabilitation.

This involves the application, when necessary, of measures to control destruction of the new vegetation by insects, rodents, livestock, and big game animals. These measures may include fencing or the use of repellents to prevent or discourage damage to the plants from such sources.

10. Rehabilitation time frames: The length of time required to successfully rehabilitate surface mined sites depends, essentially, upon the same environmental factors that determine the rehabilitation potentials of the sites. In other words, each kind of rehabilitation response unit probably has its own characteristic period of time required for successful rehabilitation under specified treatment. Assuming that rehabilitation response units having high rehabilitation potential rating can be rehabilitated quicker than those with low ratings, and considering the nature of revegetated plant cover on surface mines of relatively recent vintage in different parts of the Northern Great Plains, we can speculate with some degree of reason about rehabilitation time frames. We believe that the higher rated rehabilitation response units (which occur predominantly in North Dakota) can be rehabilitated successfully in from 1 to 5 years, depending upon whether the rehabilitation objective is agricultural cropland or mixed-grass range. On the medium-rated rehabilitation response units (which dominate the moister areas of southeastern Montana and

and northeastern Wyoming), successful rehabilitation should be achieved in from 5 to 10 years depending upon whether the rehabilitation objective is to return the land to short-grass prairie, a grass-shrub steppe, or a mixture of these types with ponderosa pine. On the lower-rated rehabilitation response units (in the drier portions of northeastern Wyoming and northeastern Montana), from 5 to 15 years may be required to successfully return the land to the short-grass and/or shrub steppe range that characterized it prior to mining. During several consecutive years of above normal precipitation, these time frames--particularly the longer ones--might be shortened substantially. On the other hand, during several consecutive years of drought, these time frames might be even lengthened, especially the short ones. Careful irrigation and fertilizing for the first several growing seasons would, no doubt, effectively shorten the time period required to achieve successful rehabilitation.

11. Rehabilitation objectives: In the Northern Great Plains, only a relatively few alternative rehabilitation objectives are feasible. The gentle topography, paucity of water, and lack of broad-scale variability in vegetation growth forms combine to limit the feasible alternatives for rehabilitation objectives. While the following objectives are not all-inclusive, they probably come close to delineating the feasible rehabilitation alternatives available in the Northern Great Plains:

a. Return as nearly as possible to original range/forest condition.

b. Return to previous agricultural cropland condition.

c. Convert from previous range/forest condition to agricultural cropland.

d. Convert from previous agricultural cropland to range/forest condition.

e. Take advantage of such specialized features as water for ponds or lakes to develop unique recreation and/or wildlife habitat areas.

f. Develop such intensified land uses as airports, industrial or residential areas, solar energy sites, etc.

V. ORGANIZATIONS PROMINENTLY ACTIVE IN NORTHERN GREAT PLAINS REHABILITATION WORK

While the railroad companies through North Dakota and Montana strip mined coal and rehabilitated some areas nearly a half century ago, by far the most surface mining activity in the Northern Great Plains Coal Province has developed within the past 7 or 8 years, and nearly all of the rehabilitation efforts have occurred within the last 5 years. The most prominently active organizations involved in surface mine rehabilitation work in the Northern Great Plains involve industry, federal agencies, and state institutions. The most effort in this respect so far has been provided by the mining industry. These efforts, however, have not always been successful, partially due to lack of adequate technical direction. The most active federal agencies in this regard have been the Agricultural Research Service, especially its laboratory at Mandan, North Dakota; the Forest Service's Intermountain and Rocky Mountain Forest and Range Experiment Stations; the Soil Conservation Service, and the Bureau of Land Management. Probably the most active state institutions have been the Agricultural Experiment Station at Montana State University and the University of Wyoming. The Montana Highway Department, although not working directly on rehabilitation of surface mined lands, has been very active in rehabilitation work on highway cuts and fills; and this work, in some instances, has direct application to surface mine rehabilitation problems.

VI. COSTS OF REHABILITATION

The costs of revegetation include shaping of the spoils, use of topsoil, seedbed preparation, seeding, fertilizing, soil amendments, mulching, and, sometimes, irrigation. The largest expenses are usually those of shaping of the land and replacing topsoil. Most estimates of rehabilitation costs emphasize either per-acre or per-ton costs. A more realistic alternative is to base costs on the stripping ratio, which is essentially basing the cost on a function of area disturbed relative to the coal produced. Thus, economic considerations favor surface mining where coal seams are thick and overburden is thin. In the Northern Great Plains resources study area, the lowest operating costs and the least area of disturbance per million tons of coal produced occurs in Wyoming and Montana where the very thick coal seams are covered by relatively thin overburden. In contrast, the highest operating costs and the greatest unit disturbance per million tons of coal mined, are found in North Dakota where the coal seams are thinner and are more deeply buried. One can note that the thickest coal seams, the thinnest overburden, and the smallest acreage mined per million tons of coal production occur in those parts of the Northern Great Plains which have the lowest rehabilitation potentials.

Conversely, the greatest acreages of mining disturbance per million tons of coal occur in those parts of the Northern Great Plains having the highest rehabilitation potentials. Estimates of direct onsite rehabilitation costs in the Northern Great Plains coalfields, including land shaping, seedbed preparation, seeding, fertilizing, soil amendments, water control on slopes, mulching, sediment control in detention basins, shrub or tree planting, and topsoil replacement, range from approximately $700 per acre to $1,800 per acre--depending upon the location and particular nature of onsite problems encountered. Considering the tonnages of coal that will be mined per acre in the Northern Great Plains, it appears that the mining operations can readily bear the full expense of rehabilitation without adding more than a few cents per ton to the price of coal.

VII. LEGAL BASIS FOR ENFORCEMENT OF SURFACE MINE REHABILITATION IN THE NORTHERN GREAT PLAINS RESOURCES STUDY AREA

We conclude on the basis of the information contained in this report, that virtually all of the surface mined lands in the Northern Great Plains can be successfully rehabilitated, albeit some more easily than others. This conclusion, however, requires some qualification. Even on those rehabilitation response units having the highest rehabilitation potentials, rehabilitation will be successful only when there is adequate preplanning both in mining and rehabilitation, and diligent monitoring and enforcement of rehabilitation over a meaningful period of time. Fulfillment of these qualifications depends upon adequate laws and administration, which, in turn, implies coordinated efforts by local, state, and federal Government agencies. The Congress of the United States is actively considering legislation to regulate surface mining. However, to date, no federal law has been adopted for the specific purpose of rehabilitating lands disturbed by mining. For the most part, neither federal nor local regulations are explicit regarding surface mining and rehabilitation. On the other hand, all the states represented within the Northern Great Plains resources study area have much more explicit laws in this regard. A summary was made of state legal requirements regarding the rehabilitation of surface mined lands in the Northern Great Plains resources study area. The information reveals that none of the states have complete legal authority covering all of the major rehabilitation requirements. The Wyoming and Montana laws in this respect appear to be the most encompassing. North Dakota's law is somewhat less stringent, and South Dakota's law appears least stringent. In only four of 18 rehabilitation requirement categories do all of the states have specifications. These are the requirements for grading and shaping spoils, for providing surface drainage, for surfacing of spoils with topsoil, and for revegetation. The differences in legal requirements for rehabilitation among just the four states involved herein illustrate succinctly the need for improved coordination of the legal aspects of surface mine rehabilitation.

VIII. INFORMATION AND RESEARCH NEEDS

At a number of places throughout this report, the need for more research and better information has been implied, evident, or stated. The more important of these informational and research needs are listed as follows:

1. Analysis and evaluation of chemical and physical characteristics of surface mine overburden materials in relation to their suitability for revegetation purposes
2. Development of methods and techniques for creating favorable microbiological activity in previously sterile surface mine spoils.
3. Test and evaluate the comparative effects of different organic soil amendments in the revegetation of surface mine spoils.

4. Test and evaluate the comparative effects of selected inorganic fertilizers in the revegetation of surface mine spoils.
5. Evaluate the physical and chemical quality of surface and subsurface runoff water from mine spoils under different rehabilitation treatments.
6. Develop mechanical-chemical-vegetative techniques for rehabilitating steep, abandoned surface mine spoils.
7. Evaluate the effectiveness of known successful semiarid farming techniques on various kinds of mine spoils.
8. Determine the limits of established techniques.
9. Test and evaluate various spoil segregations and configurations for enhancement of rehabilitation success.
10. Develop mechanical criteria for construction of mine dumps in order to prevent mass slumping and reduce surface erosion.
11. Determine the physiological tolerances of selected plant ecotypes to various soil-water potential and atmospheric evaporative demand stresses on surface mined spoil sites.
12. Determine physiological tolerances of selected plant ecotypes to saline-alkaline stresses on various kinds of surface mined spoils.
13. Test and evaluate hormone-stimulated rooting characteristics of native shrubs on abandoned, oversteep mine spoils.
14. Apply tissue-culturing techniques to develop increased tolerances of selected plant ecotypes to saline-alkaline stresses on surface mined spoils.

IX. CONCLUSIONS

This survey and analysis of rehabilitation experience and potentials of the major coal and bentonite surface mines in the Northern Great Plains indicates several rather common reclamation problems. Perhaps the most common is leaving spoil slopes too steep on the more unstable soil associations. Rilling and gullying start quickly, particularly where the spoils have high sodium contents. Such erosion washes seed and fertilizer from areas needing revegetation. It also robs moisture that is needed in the soil if plant cover is to become established and persist. Where possible, it appears that grading the slopes to permit rehabilitation work to be done cross slope is preferred. Overburden conditions that are adverse to plant growth are often overlooked, although, in many cases, probably recognized. The consistent existence of spoils that do not support any vegetative cover, although they have been exposed for a number of years, bears out this contention. Such materials should be recognized and buried.

Solutions to many conditions that have been called "problems" in the past can be achieved by practicing common sense, together with interest in and knowledge about conditions that determine plant growth. Nevertheless, there is a variability in sites within even a single rehabilitation response unit, despite the gross overall similarities that may exist in climate, soil, and vegetation. This variability in site microenvironment contains some of the constraints that negate hard and fast rules about rehabilitation potentials. Good rehabilitation will continue to require spot-by-spot application of sound principles of plant-soil-water relations.

We believe, with considerable certainty, that virtually all surface mined sites in the Northern Great Plains can be successfully rehabilitated. Sites having the highest rehabilitation potentials occur in rehabilitation response units characterized by productive and stable soils, suitable and available plant species, and adequate amounts of precipitation. In general, these high potential sites occur in west-central North Dakota. Surface minable sites having intermediate rehabilitation potentials occur predominantly in southeastern Montana and extreme western North Dakota. Sites having the poorest potentials for rehabilitation occur in northeastern Wyoming and northeastern Montana, where rehabilitation response units are characterized by poorly productive soils, native species which grow slowly and are difficult to obtain for rehabilitation purposes, and low amounts of precipitation.

Fortunately, those portions of the Northern Great Plains that present the most difficult rehabilitation problems are also the portions where the smallest areas will be disturbed for a given amount of extracted coal. Conversely, the easiest rehabilitation problems exist in those portions of the Northern Great Plains where the greatest areas of disturbance take place per unit of extracted coal.

Comparisons of the rehabilitation potential ratings (matrix "degree" values) indicate lack of uniformity in the relative ease or difficulty of the rehabilitation job with a shift from one development forecast to another and from one time frame to another. Even with the differences in areas to be mined (matrix "magnitude" values) in each forecast and time frame accounted for, substantial increases and decreases in the rehabilitation potential ratings (Table 6) exist. This means that the difficulty of the rehabilitation job will vary substantially between development forecasts and time frames. We conclude that, based on the information contained in this report, restructuring of mining developments between time frames within each development forecast could be accomplished by reselecting for mining during each time frame the combination of rehabilitation response units that are collectively of the same--or nearly the same--rehabilitation potential ratings from time frame to time frame. This would greatly enhance the uniformity of and, hence, the standardization of, rehabilitation activities and programs in the Northern Great Plains coalfields.

Neither the federal Government nor the states have adequate laws governing surface mine rehabilitation in the Northern Great Plains. There is no federal law, and the state laws do not have uniformly adequate provisions to assure the application of known technology for rehabilitation of surface mined lands. Better laws and effective enforcement will be required before even the best rehabilitation technology will be applied effectively to the land.

Although we believe that virtually all the surface mined lands of the Northern Great Plains can be rehabilitated successfully, a large amount of basic information needs to be collected, and numerous research problems require solutions before such rehabilitation can proceed expeditiously, effectively, and economically.

Discussion draft
March 1974

IMPACT ANALYSES OF COAL DEVELOPMENT ON ECOSYSTEM RELATIONSHIPS

I. INTRODUCTION

This report is a supplement to the original report (Ecosystem Relationships of the Northern Great Plains) submitted by the Ecosystem Relationships subgroup. The present report is intended to be used in conjunction with that original descriptive manuscript, which delineates and describes all the ecosystems on the northern Great Plains, and which identifies some of the major constraints that should be considered in coal development in this region.

The data presented here represent a summary of the analyses of the impacts of coal development on the ecosystems of the northern Great Plains. The sources of these data are identified in the accompanying narrative explanations of the attached tables. Methods of analysis varied for the different tables, and are explained below.

II. IMPACT ANALYSES

The relative ranking of each of the 16 ecosystems on the northern Great Plains in terms of their sensitivity to surface mine disturbances is presented in Table 1. Also listed is the relative ranking of the available water for growth. Sensitivity is ranked from +9, the most sensitive, to -7, the least sensitive. Available water is also ranked from +9, the highest available water, to -7, the least available water. It will be noticed that generally the more xeric ecosystems are the more sensitive to disturbances and are the most difficult to rehabilitate. However, the subalpine ecosystem, which has a high availability of water, is also ranked high in sensitivity. This exception occurs because of the extreme nature of the subalpine environment and the very short growing season. The floodplain ecosystem, ranked lowest in sensitivity and highest in available water, requires some additional explanation. Although the floodplain has a high degree of rehabilitation potential for recovery, its proximity to the streams and rivers of the study area make it a potentially dangerous ecosystem to disturb. Disturbances of this ecosystem will almost certainly contribute to a decrease in water quality in the streams and rivers adjacent to it, and potentially impair the aquatic ecosystems so vital to the ecological stability of the northern Great Plains. Thus, in Table 1, the floodplain is ranked as an ecosystem alone, but its potential influences on other surrounding ecosystems (aquatic or terrestrial) is reflected in a high degree of impact due to coal development and associated disturbances. Because the floodplain ecosystem has a low sensitivity and high available water does not mean that the impacts of mining will be slight. This point is illustrated in the matrix tables to be discussed below.

The ecosystems occurring in the four sample counties have been ranked in terms of sensitivity to disturbance in Table 2. All of the ecosystems that occur in these counties have been listed, including those that do not overlay coal deposits or that will not otherwise be mined. Based on these and the rankings in Table 1, Campbell County, Wyoming is the driest sample area containing the largest area of more sensitive ecosystems to disturbance. Rosebud and Big Horn counties, Montana, are intermediate, and Mercer-Oliver counties in North Dakota are more moist and least sensitive, respectively.

The areas occupied by each ecosystem on the northern Great Plains is listed in Table 3, together with the percent of the total area. Also shown is the area of each ecosystem occurring in the four sample counties, and the percent of the total county area they cover. At the bottom of the table is shown the total areas in square miles of the region and four sample counties. These data are quite revealing when contrasting the potential impacts of coal development of the different sample counties. For instance, over 90 percent of the land area of Campbell County, Wyoming, is composed of arid and sensitive ecosystems, whereas 100 percent of the Mercer-Oliver counties area is composed of mesic to wet and moderately sensitive to low-sensitive ecosystems. Also, it is interesting to note that none of the areas proposed for extensive coal development on the northern Great Plains is composed of the most sensitive and arid ecosystems. These data were collected from the map in Appendix E of the Regional Profile Report.

The area of strippable coal on the northern Great Plains, by ecosystem, is presented in Table 4. These data show quite clearly that the bulk of the coal underlies ecosystems that are in the sensitive to moderately sensitive categories. Of particular interest are the statistics on the percent of the total area of each ecosystem underlain by coal. For example, 14.6 percent of the total sagebrush-steppe ecosystem is underlain by coal deposits. This is particularly concerning because this ecosystem is highly sensitive to disturbance, and is very arid. Additionally, the rate of reoovery in this ecosystem is extremely slow. A similar concern could be expressed for the ponderosa pine ecosystem, 7.2 percent of which is underlain with coal. While this is not a particularly sensitive or arid ecosystem, it is vitally important wildlife habitat, and occupies the slopes of many of the watersheds in the study area. These data were taken from the maps of strippable coal deposits prepared by the mineral resources workgroup.

The area to be disturbed by coal development in the four sample counties by year (1980, 1985, 2000) and by forecast (base, most probable, and extensive) is presented in Table 5. An additional column showing the area to be disturbed per year after the year 2000 is also presented. For each ecosystem affected, the square miles disturbed are shown. Also shown is the percent of the area of each ecosystem in the county affected, and the percent of the total ecosystem area in the region. The percentage values are presented to the nearest hundredth of a percentage point in order to accommodate the smaller areas affected. For example, for Campbell County under the base forecast of 1980, the grassland-sagebrush ecosystem will have 0.55 square mile disturbed, which represents only two hundredths of a percent of the total area of that ecosystem in the county. The percent of the total ecosystem area in the region that is affected by disturbances in Campbell County in 1980 under this forecast is less than one hundredth of a percent, and hence appears as zero. Zeros ("0") indicate that the ecosystem is not directly affected by surface mining. The total area in square miles for the county, the percent of the total county area, and the percent of the regional area are all presented for each forecast for each year. The area figures were calculated from data furnished by the Minerals Resources Workgroup, and the percentage data were calculated from figures in Table 3.

In addition to the area data, Table 5 also identifies those ecosystems in each county that will be affected directly by surface mining. It is interesting (and relieving, too!) to note that the bulk of the mining activity will occur in ecosystems that are not extremely sensitive or arid. This is particularly so in Campbell County, which has a large area of highly sensitive ecosystems.

Besides strip mining, the data in Table 5 include impacts due to power generating plants, coal gasification plants, export mines, and associated developments. Data for transmission lines, railroads, highways, reservoirs, and other developments are included only for the extensive forecast for the year 2000.

The area in square miles that each ecosystem will be disturbed in a regional basis is shown in Table 6. These data show the square miles of disturbance and the percent of the total area affected of each ecosystem for the base, most probable, and extensive forecasts for the three time frames. These figures show that, in terms of area, the mid-grass prairie and the grassland-sagebrush ecosystems will receive the bulk of the direct disturbance. However, perhaps of greater concern is the impact on the ponderosa pine ecosystem which will be disturbed to a proportionately greater extent than any other ecosystem under the base and most probable forecasts. Under the extensive forecast the potential impacts of transmission lines, roads, railroads, and aquaducts is included with surface mine disturbances. Here the badlands, short grass prairie, and Black Hills pine ecosystems are affected.

Tables in the analysis show the degree and magnitude assessments of coal development impacts on the ecosystems of Campbell, Rosebud, Big Horn, and Mercer-Oliver counties, respectively. These tables are for the three forecasts and three time frames. The values for the degree of impact range potentially from 0 to -9, where 0 reflects the impact of no coal development, and -9 reflects maximum disturbance. The magnitude values were taken from Table 5, and are the percentages of the total ecosystem in that county. For example, in the case of the grassland-sagebrush ecosystem, under the 1980 base forecase, it will be disturbed to a magnitude of two hundredths of one percent (0.02%) of its total area in Campbell County and the degree of impact is rated as -1. The value for degree of impact applies to the entire ecosystem in the county, and implies the overall effect that disturbance will have on the stability of the ecosystem, its dynamics, and potential recoverability.

The relationship between degree and magnitude is nearly linear for any given ecosystem, but the relationship is not the same for all ecosystems. For example the greater the sensitivity of an ecosystem (Table 1), the greater the degree of impact will be for a given magnitude of disturbance. This relationship is illustrated in Figure 1, wherein the least sensitive ecosystems to disturbance are affected to a lesser degree at a given magnitude of development than are the moderately or very sensitive ecosystems. This relationship is further illustrated in analysis of the base forecast for the year 2000, wherein the grassland-sagebrush ecosystem is ranked at a degree of -4 for a magnitude of 1.15%. However, ponderosa pine is ranked at a degree of only -3 for a similar magnitude of 1.19%. This difference in degree reflects the greater sensitivity of the grassland-sagebrush ecosystem to disturbance.

In our analysis tables, a (0) value indicated that no degree or magnitude impact will be received by that ecosystem for that year and forecast. However, a dash (-) indicated that some unknown magnitude of disturbance may be experienced indirectly as a result of surface mining. In those cases where some indirect impact is anticipated, a rating for degree of impact was also given.

The total impact for each county reflects the sum of the magnitude of all ecosystems. The total degree of impact is a subjective value arrived at through integration of the levels of sensitivities for each ecosystem. An arithmetic mean would really not reflect the true degree of impact because of the nonlinearity of the ratings between ecosystems.

Tables were constructed to show the degree and magnitude of disturbance ratings of the impacts of projected coal development for the four sample counties for the three forecasts for 1980, 1985, and 2000, respectively. Similar rating schemes and numerical values were used throughout all analyses. In addition to constructing matrix tables to rate impacts in the sample counties, similar tables were devised on a regional basis for the three development forecasts and three time frames.

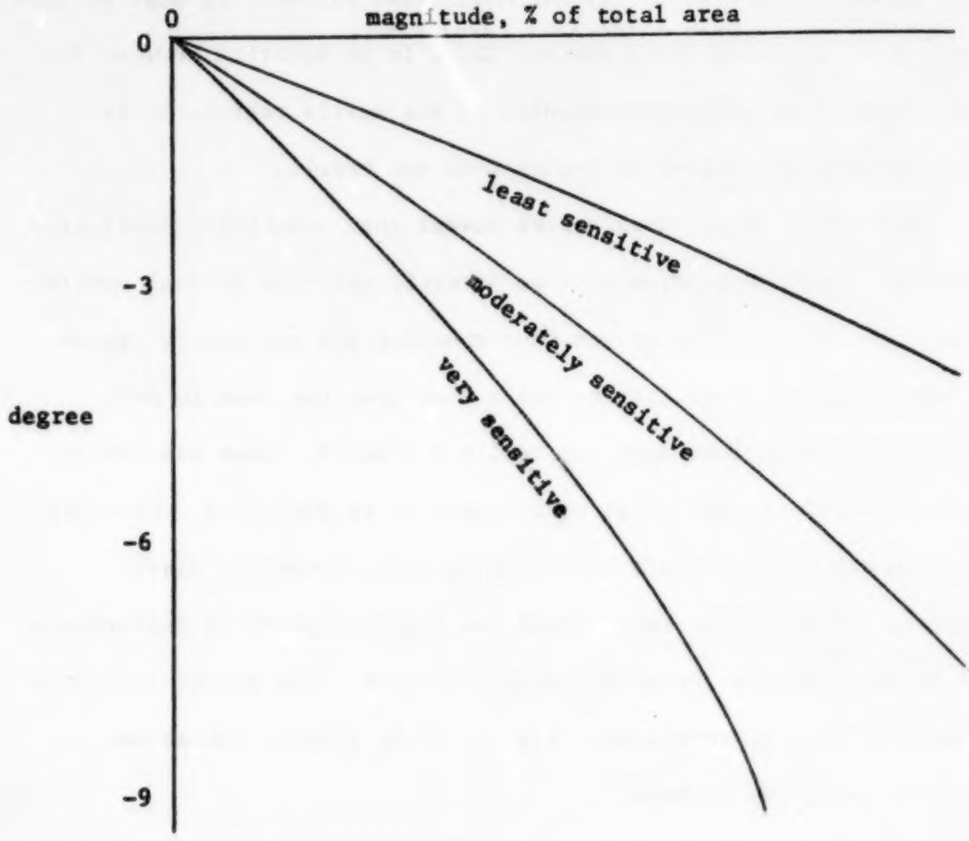

Figure 1. The relationship between magnitude (percent of total ecosystem area disturbed) and degree of impact (ranked from 0 to -9) for the sensitivities of the various ecosystems.

III. CONCLUSIONS

An examination of the matrix tables made for the analyses will permit a general assessment of the potential impacts of coal development on the ecosystems of the northern Great Plains. It must be made clear that, in using these tables, there is no equation between the percentage of an ecosystem, county, or the entire region, to be disturbed and the degree of impact that may result.

At first glance, these tables reveal that relatively small proportions of each ecosystem will be directly affected by coal development. The same is true of the four counties and the entire region. In some respects these figures are a trap that can lead to more optimistic conclusions than are really warranted. When one realizes that only 0.05 percent of an ecosystem will be disturbed, the first reaction may be that there is really no major cause for alarm. However, these figures only reveal the direct impacts of disturbance, and do not indicate the more indirect effects. The almost insidious effects of mineral development are, at first glance, subtle and somewhat below the surface.

Such almost subtle relations as the nesting areas for key symbiotic insects and annual plants, or the niches for certain soil microorganisms or endangered vascular plant species must be considered. Also, these figures do not reveal the indirect human impacts, such as the effects of increased recreational pressures. How many more hunting and fishing licenses will be sold during the next 25 years, and what effect will these have on animal population dynamics and their relationship with the native flora? What effects will result from increased numbers of snowmobiles, dune buggies, and trail bikes on arid sensitive ecosystems, and increased camping pressures? There is some real danger that may result from the increased rate of water use from the native streams and rivers; as was pointed out in the main report on Ecosystem Relationships, these sources of water are vital to the terrestrial and aquatic populations of animals on the northern Great Plains. Thus, the values in the matrix analysis tables are revealing on one hand, but conceal certain relations on the other.

The matrix data indicate that the most severe impacts will result on the moderately arid ecosystems, and that the counties that support them will be affected most detrimentally. They reveal, as expected, that the base forecast will lead to the least disturbance, and the extensive forecast would result in the most. A similar conclusion can be drawn about the entire region. Generally, however, it can be concluded that some ecosystem relationships will be disrupted for many generations to come under all three forecasts, and indeed, some may be lost forever. It would seem to be highly presumptuous at this point to pompously make a decision as to what relationships we can forego, when we scarcely know the kinds of complex ecological interactions that exist in the first place.

Table 1. Relative ranking of ecosystems in terms of sensitivity to surface disturbances and of available water for growth.

		Ecosystem	Sensivity to surface disturbance[1]	Available water [2]
Wet	Very sensitive	Subalpine	+9	+8
Semiarid		Badlands	+7	-7
		Short-grass prairie	+6	-6
		Sagebrush-steppe	+5	-5
		Grassland sagebrush	+4	-4
	Moderately sensitive	Mid-short grass prairie	+3	-3
		Mid-grass prairie	+2	-2
		Ponderosa pine forest	+1	-1
		Grassland-sandsage	0	0
		Foothills grassland	-1	+1
		Mid-tall grass prairie	-2	+2
Mesic		Prairie-oak savanna	-3	+3
	Least sensitive	Douglas-fir--ponderosa pine forest	-4	+4
		Black Hills pine forest	-5	+5
		Douglas-fir forest	-6	+6
Hydric		Floodplain	-7	+9

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[1] Relative sensitivity to surface disturbance is ranked from +9 to -7, wherein +9 is the most sensitive, and -7 is the least sensitive.

[2] Relative available water for growth is ranked from +9 to -7, wherein +9 is the highest relative available water for growth, and -7 is the leas

Table 2. Relative position of the ecosystems in each of the sample counties according to the availability of water and sensitivity to disturbance

<table>
<tr><th></th><th>Campbell Co. Wyo.</th><th>Rosebud Co. Mont.</th><th>Big Horn Co. Mont.</th><th>Mercer-Oliver Co.'s N. D.</th></tr>
<tr><td>Semi-arid more sensitive ↑</td><td>short grass→</td><td></td><td></td><td></td></tr>
<tr><td>↕</td><td colspan="2">← sagebrush-steppe →</td><td></td><td></td></tr>
<tr><td>↕</td><td colspan="3">← grassland-sagebrush →</td><td></td></tr>
<tr><td>↕</td><td></td><td colspan="2">← mid-short grass →</td><td></td></tr>
<tr><td>↕</td><td></td><td></td><td></td><td>← mid-grass →</td></tr>
<tr><td>↕</td><td colspan="3">← ponderosa pine →</td><td></td></tr>
<tr><td>↕</td><td></td><td></td><td>← foothills grass →</td><td></td></tr>
<tr><td>↕</td><td></td><td></td><td>Douglas-fir →</td><td></td></tr>
<tr><td>↓ less sensitive wet</td><td colspan="4">← floodplain →</td></tr>
</table>

Table 3. Area occupied by each ecosystem in the NGPRP study area in square miles, and in percent of the total area. Also, area of each ecosystem occurring in each sample county, and the percent of the total county occupied by each ecosystem.

	Ecosystem	Total region		Campbell Co.		Rosebud Co.		Big Horn Co.		Mercer-Oliver Co.'s	
		Sq.mi.	%	Sq.mi.	%	Sq.mi.	%	Sq.mi.	%	Sq.mi.	%
1.	Floodplain	5,750	4.1	73	1.5	225	4.5	85	1.7	245	13.9
2.	Badlands	4,583	3.3	--	--	--	--	--	--	--	--
3.	Short-grass	8,721	6.2	55	1.2	--	--	--	--	--	--
4.	Mid-short grass	20,805	14.7	--	--	2,705	53.7	2,983	59.4	--	--
5.	Mid-grass	55,997	39.6	--	--	--	--	--	--	1,517	86.1
6.	Grassland-sagebrush	22,811	16.13	3,607	75.9	1,280	25.4	555	11.1	--	--
7.	Sagebrush-steppe	1,388	0.9	677	14.2	12	0.3	--	--	--	--
8.	Grassland-sandsage	411	0.3	--	--	--	--	--	--	--	--
9.	Mid-tall grass	7,384	5.2	--	--	--	--	--	--	--	--
10.	Foothills grassland	1,428	1.0	--	--	--	--	884	17.6	--	--
11.	Prairie oak savanna	442	0.3	--	--	--	--	--	--	--	--
12.	Ponderosa pine	5,722	4.0	344	7.2	815	16.2	353	7.0	--	--
13.	Black Hills pine	1,994	1.4	--	--	--	--	--	--	--	--
14.	Douglas-fir	1,509	1.1	--	--	--	--	163	3.3	--	--
15.	P. pine-Douglas-fir	885	0.6	--	--	--	--	--	--	--	--
16.	Subalpine	1,618	1.2	--	--	--	--	--	--	--	--
	Total	141,448	100.0	4,756	100.0	5.037	100.0	5,023	100.0	1,762	100.0

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Table 4. Area in square miles of strippable coal for each ecosystem on the northern Great Plains.

	Square miles strippable coal	Percent of total ecosystem area	Percent of total strippable coal area
Floodplain	82	1.4	2.1
Badlands	47	1.0	1.2
Short-grass	275	3.2	7.0
Mid-short grass	574	2.7	14.7
Mid-grass	1,393	2.5	35.6
Grassland-sagebrush	888	3.9	22.7
Sagebrush-steppe	202	14.6	5.2
Grassland-sandsage	0	0	0
Mid-tall grass	39	0.5	1.0
Foothills grassland	0	0	0
Prairie oak savanna	0	0	0
Ponderosa pine	412	7.2	10.5
Black Hills pine	0	0	0
Douglas-fir forest	0	0	0
Pine-Douglas-fir	0	0	0
Subalpine	0	0	0
TOTAL	3,912	2.8	100.0

Table 5. Area in square miles disturbed by surface mining and associated developments in the four sample counties by ecosystem for the three forecasts and four time frames.

CAMPBELL COUNTY, WYOMING

Ecosystem	1972	1980	1985	2000	Per year after 2000
Base Forecast					
Grassland-sagebrush	0.48	0.55	4.24	14.46	0.86
% county[1/]	0.01	0.02	0.12	0.40	0.02
% region[2/]	0.00	0.00	0.02	0.06	0.00
Total for county	0.48	0.55	4.24	14.46	0.86
% county area[3/]	0.01	0.02	0.12	0.40	0.02
% regional area[4/]	0.00	0.00	0.02	0.06	0.00
Most Probable Forecast					
Grassland-sagebrush	0.48	0.88	7.58	24.05	1.05
% county	0.01	0.02	0.21	0.66	0.03
% regional	0.00	0.00	0.03	0.10	0.00
Sagebrush-steppe	0	0	0	0.63	0.40
% county	0	0	0	0.09	0.06
% regional	0	0	0	0.05	0.03
Total for county	0.48	0.88	7.58	24.69	1.45
% county area	0.01	0.02	0.16	0.52	0.03
% regional area	0.00	0.00	0.01	0.02	0.00
Extensive Forecast					
Grassland-sagebrush	0.48	1.21	16.62	48.85	2.55
% county	0.01	0.03	0.46	1.35	0.07
% regional	0.00	0.00	0.07	0.22	0.01
Ponderosa pine	0	0	0.28	3.03	0.32
% county	0	0	0.08	0.88	0.09
% regional	0	0	0.00	0.05	0.00
Sagebrush-steppe	0	0	2.72	18.54	2.68
% county	0	0	0.40	2.74	0.39
% regional	0	0	0.19	1.34	0.19
Total for county	0.48	1.21	19.62	70.43	5.55
% county area	0.01	0.03	0.41	1.48	0.12
% regional area	0.00	0.00	0.01	0.05	0.00

Table 5 (Cont)

ROSEBUD COUNTY, MONTANA

Ecosystem	1972	1980	1985	2000	Per year after 2000
Base Forecast					
Grassland-sagebrush	0.66	2.01	5.02	14.75	1.42
% county	0.05	0.16	0.39	1.15	0.11
% regional	0.00	0.01	0.02	0.06	0.01
Ponderosa pine	0.36	1.21	3.34	9.74	0.43
% county	0.04	0.14	0.41	1.19	0.05
% regional	0.00	0.02	0.06	0.17	0.01
Total for county	1.03	3.22	8.37	24.49	1.84
% county area	0.02	0.06	0.17	0.49	0.04
% regional area	0.00	0.00	0.01	0.02	0.00
Most Probable Forecast					
Grassland-sagebrush	0.66	2.01	7.30	26.61	2.81
% county	0.05	0.16	0.57	2.08	0.22
% regional	0.00	0.01	0.03	0.12	0.01
Ponderosa pine	0.36	1.21	3.95	16.18	0.81
% county	0.04	0.15	0.48	1.99	0.09
% regional	0.01	0.02	0.07	0.28	0.01
Total for county	1.03	3.22	11.27	42.79	3.62
% county area	0.02	0.06	0.22	0.85	0.07
% regional area	0.00	0.00	0.01	0.03	0.00
Extensive Forecast					
Grassland-sagebrush	0.66	4.29	19.43	64.36	3.82
% county	0.05	0.34	1.52	5.03	0.30
% regional	0.00	0.02	0.09	0.28	0.02
Ponderosa pine	0.36	1.21	4.75	23.14	2.63
% county	0.04	0.15	0.58	2.84	0.32
% regional	0.01	0.02	0.08	0.40	0.40
Floodplain	0	0	0	0.39	0.28
% county	0	0	0	0.17	0.12
% regional	0	0	0	0.01	0.00
Total for county	1.03	5.50	24.18	87.89	6.73
% county area	0.02	0.11	0.48	1.74	0.13
% regional area	0.00	0.00	0.02	0.06	0.00

Table 5 (Cont)

BIG HORN COUNTY, MONTANA

Ecosystem	1972	1980	1985	2000	Per year after 2000
Base Forecast					
Grassland-sagebrush	0.26	0.38	1.82	6.95	0.41
% county	0.05	0.07	0.33	1.25	0.07
% regional	0.00	0.00	0.01	0.03	0.00
Mid-short grass	0	0	0.64	1.86	0.08
% county	0	0	0.02	0.06	0.00
% regional	0	0	0.00	0.01	0.00
Ponderosa pine	0	0	0	0.54	0.07
% county	0	0	0	0.15	0.01
% regional	0	0	0	0.01	0.00
Total for county	0.26	0.38	2.46	9.35	0.56
% county area	0.01	0.01	0.05	0.19	0.01
% regional area	0.00	0.00	0.00	0.01	0.00
Most Probable Forecast					
Grassland-sagebrush	0.26	0.93	3.76	10.81	0.56
% county	0.05	0.16	0.68	1.95	0.01
% regional	0.00	0.00	0.02	0.05	0.00
Mid-short grass	0	0	0.64	3.86	0.24
% county	0	0	0.02	0.13	0.01
% regional	0	0	0.00	0.02	0.00
Ponderosa pine	0	0	0	4.71	0.22
% county	0	0	0	1.33	0.06
% regional	0	0	0	0.08	0.00
Floodplain	0	0	0.99	1.99	0.07
% county	0	0	1.16	2.34	0.08
% regional	0	0	0.02	0.03	0.00
Total for county	0.26	0.93	5.39	21.37	1.09
% county	0.01	0.02	0.12	0.43	0.02
% regional	0.00	0.00	0.00	0.02	0.00
Extensive Forecast					
Grassland-sagebrush	0.26	2.68	7.67	26.34	1.99
% county	0.05	0.48	1.38	4.75	0.36
% regional	0.00	0.01	0.03	0.12	0.01
Floodplain	0	0	0.99	1.99	0.07
% county	0	0	1.16	2.34	0.08
% regional	0	0	0.02	0.03	0.00
Mid-short grass	0	0	2.64	12.29	0.73
% county	0	0	0.08	0.41	0.02
% regional	0	0	0.01	0.06	0.00
Ponderosa pine	0	0	0	0.97	0.27
% county	0	0	0	0.27	0.08
% regional	0	0	0	0.02	0.00
Total for county	0.26	2.68	11.30	41.59	3.05
% county area	0.01	0.05	0.23	0.81	0.06
% regional area	0.00	0.00	0.01	0.03	0.00

Table 5 (Cont)

MERCER-OLIVER COUNTIES, N.D.

Ecosystem	1972	1980	1985	2000	Per year after 200
Base Forecast					
Mid-grass prairie	1.43	4.99	10.31	27.34	1.94
% counties	0.09	0.33	0.68	1.80	0.13
% regional	0.00	0.01	0.02	0.05	0.00
Total for counties	1.43	4.99	10.31	27.34	1.94
% county area	0.08	0.28	0.58	1.55	0.11
% regional area	0.00	0.00	0.01	0.02	0.00
Most Probable Forecast					
Mid-grass prairie	1.43	4.99	13.25	50.93	4.80
% counties	0.09	0.33	0.87	3.36	0.32
% regional	0.00	0.01	0.02	0.09	0.01
Total for counties	1.43	4.99	13.25	50.93	4.80
% county area	0.08	0.28	0.75	2.89	0.27
% regional area	0.00	0.00	0.01	0.04	0.00
Extensive Forecast					
Mid-grass prairie	1.43	10.89	30.19	107.73	9.97
% counties	0.09	0.72	1.99	6.83	0.66
% regional	0.00	0.02	0.05	0.19	0.02
Total for counties	1.43	10.89	30.19	107.73	9.97
% counties area	0.08	0.62	1.71	6.11	0.57
% regional area	0.00	0.01	0.02	0.08	0.01

1/ Percent of the area of that ecosystem in the county.

2/ Percent of area of that ecosytem in the NGPRP region.

3/ Percent of the total county area.

4 Percent of the total NGPRP regional area.

Table 6. Square miles of each ecosystem disturbed by surface mining on the NGPRP study area: regional profile.

	Base Forecast							
Ecosystem	1980		1985		2000		Per year after 2000	
	Sq. Mi.	%Region[1/]	Sq. Mi.	%Region	Sq. Mi.	%Region	Sq. Mi.	%Region
Mid-short	–	–	0.64	0.00	2.81	0.01	0.56	0.00
Mid-grass	6.15	0.01	12.60	0.02	35.32	0.06	3.76	0.00
Grass-sage.	3.20	0.01	11.47	0.05	38.28	0.17	3.28	0.01
Pond. pine	1.47	0.03	3.47	.07	11.1	0.19	0.53	0.01
Total	10.82	0.01	28.45	0.02	87.51	0.06	8.13	0.01

Table 6.(Cont)

Most Probable Forecast

Ecosystem	1980		1985		2000		Per year after 2000	
	Sq. Mi.	%Region	Sq. Mi.	%Region	Sq. Mi.	%Region	Sq. Mi.	%Region
Floodplain			0.99	0.01	1.99	.03	0.07	0.00
Mid-short			0.64	0.00	4.81	0.02	0.72	0.00
Mid-grass	6.15	.01	19.38	.03	95.56	.17	13.40	.02
Grass-sage	4.08	.02	21.67	.09	71.06	.31	5.32	.02
Sage.-steppe					0.63	0.05	0.40	.03
Pond. pine	1.47	.03	4.35	.08	23.82	.42	1.31	.02
Total	11.70	0.01	47.03	.03	197.86	0.14	21.22	.02

Table 6. (Cont)

Extensive Forecast

	1980		1985		2000[2]		Per year after 2000	
	Sq. Mi.	%Region	Sq. Mi.	%Region	Sq. Mi.	%Region	Sq. Mi.	%Region
Floodplain					9.0	.16	0.28	.00
Badlands					2.1	.04		
Short-grass					13.01	.15	3.95	.05
Mid-short			2.64	.01	24.14	.12	1.21	.01
Mid-grass	17.98	.03	53.99	.10	266.84	.48	26.16	.05
Grass-sage.	10.53	.05	52.09	.23	246.92	1.08	11.13	.05
Sage-steppe			2.72	.20	20.04	1.44	2.96	.21
Pond. pine	1.47	.03	5.43	.10	35.93	.62	3.88	.07
Black Hills					1.7	.08		
Total	29.98	.02	116.87	.08	619.7	0.44	49.57	.04

[1] Percent of total area of each ecosystem

[2] Includes area projected for transmission lines, towers, highways, aquaducts, reservoirs, and railroads.